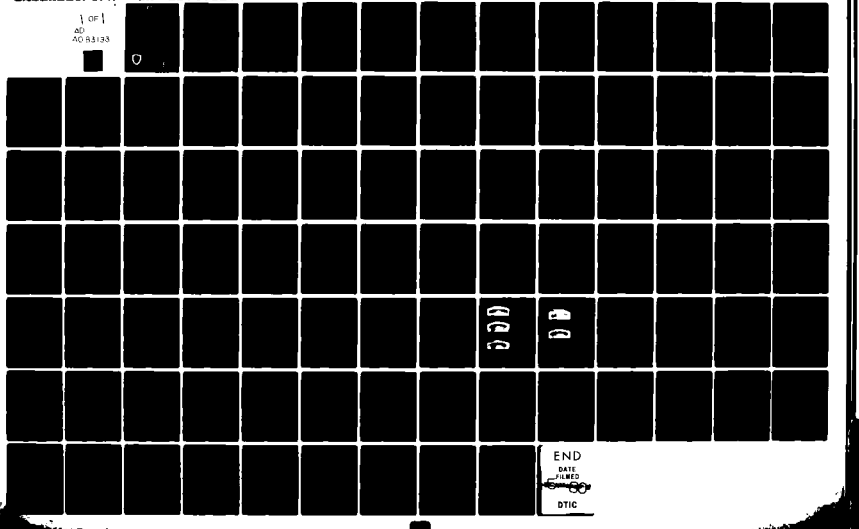
AD-A083 133 SKF TECHNOLOGY SERVICES KING OF PRUSSIA PA F/G 11/6
ESTABLISHMENT OF THE MATERIAL FACTOR FOR VIMVAR M-50 TOOL STEEL--ETC(U)
AUG 79 F R MORRISON, J I MCCOOL, N J NINOS DAAK50-78-C-0027
UNCLASSIFIED SKF-AL79T027 NL

1 OF 1
AD
A083133



END
DATE FILMED
DTIC

LEVEL II

12
A.S.

AVRADCOM

TECHNICAL REPORT TR 79 - 48

AD

4. TITLE (and Subtitle)

Establishment of the Material Factor for VIMVAR M-50 Tool Steel For Use in Rolling Bearing Life Calculations

FRANK R. MORRISON

JOHN I. McCOOL

NICHOLAS J. NINOS

AUGUST 1979

U.S. ARMY AVRADCOM

Approved for public release; distribution unlimited.

DISCLAIMER STATEMENT

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

AVRADCOM

TECHNICAL REPORT TR 79 - 48

AD

4. TITLE (and Subtitle)

Establishment of the Material Factor for VIMVAR M-50 Tool Steel For Use in Rolling Bearing Life Calculations

FRANK R. MORRISON

JOHN I. McCOOL

NICHOLAS J. NINOS

SKF TECHNOLOGY SERVICES

1100 FIRST AVENUE

KING OF PRUSSIA, PA. 19406

AUGUST 1979

PREPARED FOR

UNITED STATES ARMY

AVIATION RESEARCH AND DEVELOPMENT COMMAND

ST. LOUIS, MO 63166

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. 3. RECIPIENT'S CATALOG NUMBER (9)
4. TITLE (and Subtitle) (C) Establishment of the Material Factor for VIMVAR M-50 Tool Steel For Use in Rolling Bearing Life Calculations.	5. TYPE OF REPORT & PERIOD COVERED Final Report 27 Dec 1978 to 31 Aug 1979
	6. PERFORMING ORG. REPORT NUMBER (14) SKF Report-AL79T027
7. AUTHOR(s) (10) Frank R. Morrison, John I. McCool, Nicholas J. Ninos	8. CONTRACT OR GRANT NUMBER(s) (15) DAAK50-78-C-0027
9. PERFORMING ORGANIZATION NAME AND ADDRESS SKF Technology Services, 1100 First Avenue, King of Prussia, Pa. 19406	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (11)
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Aviation Research & Development Command, P. O. Box 209, St. Louis, Missouri 63166	12. REPORT DATE 24 August 1979
	13. NUMBER OF PAGES 74
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 89	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

Accession For	
NTIS GRA&I	☑
DDC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	23

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Bearing Fatigue Life
M-50 Steel Life
Bearing Life Calculation Factors
Bearing Life Survey
VIMVAR M-50 Steel Bearings

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Material and lubrication factors for M-50 steel rolling contact bearings have been determined via a survey accumulating life results from previously conducted test programs. Experimental life results are presented on five groups of angular contact ball bearings manufactured from VIMVAR M-50 steel and run under several load speed and lubrication conditions.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

411067

Summary

In 1948 and 1952, Lundberg-Palmgren published the definative basic work on the prediction of rolling bearing fatigue life utilizing empirical factors based on existant technology. Newer materials and processing techniques are now providing the means to improve bearing life. Since 1950, a considerable amount of information has been generated on rolling bearings manufactured from materials other than conventional 52100 steel. In addition, the effects of certain bearing operational parameters on bearing life have been studied. As a consequence, modifying factors, accounting for the influence of materials, processing techniques and equipment operational characteristics, i.e. oil film thickness and speed, have been defined and can now be employed in the estimation of bearing fatigue life.

The current industry formulation of the rolling bearing life calculation equation is $L_n' = a_1\ a_2\ a_3\ (C/P)^w$, where w is 3 for point contact and 10/3 for line contact. Life modification factors, a_1, a_2, and a_3, allow the user to consider increases in bearing life produced by technological advances and the influence of the specific application conditions. One of these factors, a_2, is related to the material analysis and material processing variables. It is an important consideration in rating bearings for Army helicopter applications where multiple vacuum processed (VIMVAR) M-50 tool steel is most commonly used.

The Department of the Army has a need to verify the material and application life factors of rolling element bearing life calculations in order to more accurately rate the life potential of rolling bearings over the entire range of service applications seen in Army helicopters.

In Phase I of a study conducted for the U. S. Army Aviation Research and Development Command (AVRADCOM) under contract No. DAAK50-77-C-009, reported in AVRADCOM TR 79-35, a survey was conducted to accumulate life data achieved from rolling contacts manufactured from M-50 tool steel and these data were statistically analyzed. Material and lubrication factors were determined using this data base, enabling a more accurate calculation of the potential life of a bearing. In addition, experimental endurance life data were accumulated on three specific groups of rolling bearings manufactured to Vacuum Induction Melted Vacuum Arc Remelted (VIMVAR) M-50 steel.

The current work reported here in under Phase II is a continuation of this work conducted under U. S. Army Contract Number DAAK50-78-C-0027. The existing data base has been expanded with the addition of experimental endurance life data obtained on five 10 bearing lots of 7309 angular contact ball bearings manufactured from VIMVAR M-50 tool steel. These groups were tested under various conditions so that the effects of lubricant type, viscosity, speed and operating temperature on the life modification factors could be evaluated.

Additionally, the data base was statistically interrogated to establish whether any systematic life variations existed as functions of variations in the defined operating parameters.

PREFACE

This report presents the results of an analytical and experimental study conducted by SKF Technology Services for the U. S. Army Aviation Research and Development Command, St. Louis, Missouri 63166 under Contract No. DAAK50-78-C-0027. This report encompasses effort conducted from 27 December 1978 to 31 August 1979.

Technical direction for the U. S. Army was provided by Mr. Harold Schuetz, the Contracting Officers Representative.

The principal investigators from the SKF Mechanical Laboratories who worked on this project were Mr. N. J. Ninos - Scientist and Project Leader: Mr. F.R. Morrison - Supervisor, under whose direction the work was accomplished; and Mr. J. I. McCool - Senior Mathematician who performed the statistical data analysis.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

I. INTRODUCTION

A. Background and Objectives

Rolling bearing fatigue life was originally quantified through life prediction theories developed by Lundberg-Palmgren [1 and 2]. Subsequently, these theories were adopted by the International Standards Organization, the American National Standards Institute and the majority of rolling bearing manufacturers in the world as the primary means of predicting bearing lives for potential applications. The empirical factors included in these theories were based on 52100 type steel bearing data collected prior to 1950.

According to the formulas developed by Lundberg and Palmgren, the estimated life that 90% of a group of bearings will achieve or 10% of the bearings will fail before are:

for Ball Bearings $\quad L_{10} = \left(\frac{C}{P}\right)^{3}$

for Roller Bearings $\quad L_{10} = \left(\frac{C}{P}\right)^{10/3}$

where:

L_{10} = Rating life in millions of revolutions

C = Basic load rating in pounds. (The load which will give a rating life of one million revolutions)

P = Equivalent radial load, lbs.

[1] Lundberg, G. and Palmgren A., "Dynamic Capacity of Rolling Bearings", Acta Polytechnica, Mechanical Engineering Series 1, Proceedings of the Royal Swedish Academy of Engineering, Vol. 7, No. 3, 1947.

[2] Lundberg, G. and Palmgren A., "Dynamic Capacity of Roller Bearings", Proceedings of the Royal Swedish Academy of Engineering, Vol. 2, No. 4, 1952.

However, technological advances in the areas of bearing design, materials and manufacturing techniques have significantly increased the actual fatigue life of bearings. Life predictions calculated by the Lundberg-Palmgren method may be conservative, and a new life calculation formulation is required to accurately reflect the available life improvements. Concurrently, a better understanding of the influence of system operational factors on bearing performance and longevity has been established. These parameters are now taken into consideration when determining the expected life of a bearing according to the following formula:

$$L_n' = a_1 \, a_2 \, a_3 \, L_{10}$$

where:

L_n' = the adjusted theoretical fatigue life

a_1 = life adjustment factor for reliability (90%=1)

a_2 = life adjustment factor for bearing material

a_3 = life adjustment factor for application conditions

The inclusion of the a_2 a_3 life adjustment factors in the formulation allow the user to consider the effects of bearing material and operating conditions on the potential life of the system. These are important considerations in rating bearings for Army helicopter applications where a wide range of operating conditions are experienced and where a premium long life bearing material, vacuum melt M50, is utilized.

At the present time the values assigned to the a_2 a_3 factors for these calculations vary and depend upon the specific recommendations of the airframe or engine manufacturer and bearing supplier involved in each individual design case. Reasons given for the existence of these variations range from differences in experimentally collected life data, to differences in environmental conditions which do not adequately take into account the influence of the a_3 application factor. The ambiguity in the calculation of the theoretical life of a given bearing design caused by the inconsistency in the values assigned to these factors makes it difficult to evaluate the potential adequacy of a proposed helicopter system design. The need existed, therefore, to establish a consistent base value of a_2 for vacuum melt M-50 material, and to examine the quantification of the material-application factor combination a_2 a_3 over the entire range of conditions encountered in helicopter applications.

The direct establishment of a factor modifying the bearing life formula is an extensive task. Rolling bearing life is a statistical function that contains a significant degree of scatter within any one experimental lot. Furthermore, significant life variations are noted between experimental lots as a result of yet undefined variations of material melt lot, manufacturing processes, environmental conditions, etc. Therefore, it is necessary to consider a large volume of data prior to the establishment of statistically valid life modifying factors.

A significant amount of life test data accumulated under a variety of test conditions now exist from bearing and element test specimens which were manufactured of vacuum processed, CVM (consumably vacuum melted) and VIMVAR (vacuum induction melted, vacuum arc remelted) M-50 tool steel. These data were compiled along with the respective test conditions, under Phase I of a program sponsored by AVRADCOM under Contract No. DAAK50-77-C-009 and reported in AVRADCOM TR 79-35 to form the basis for the derivation of a value for the material factor a_2.

The statistical treatment of these data yielded a best estimate of the a_2 material factor for both CVM and VIMVAR processed M-50 tool steel of 3.55. This suggests that for most aerospace applications where good lubrication exists, i.e. indicating a lubricant film factor of 2 to 3, the use of a total life multiplication value, a_2 a_3, ranging from 6 to 10 is justified.

The data base used to generate these preliminary estimates contained only a small number of VIMVAR processed lots. Thus the values are strongly biased by the CVM processed lots. VIMVAR is now the standard melting process used for M50 steel and it is expected to provide a further life increase over that available from CVM processed material. The aim of Phase II was to extend the data base for VIMVAR M-50 tool steel bearings by adding life information based upon several specific combinations of operational conditions. These additional data will strengthen the statistical significance of the estimated value of the life factor for VIMVAR processed M-50 tool steel.

Additionally, during the Phase I effort, the data base was interrogated to establish if the effects of some basic parameters considered to be inherent in the life estimation process, eg. size, stress, lubricant film effects, were adequately considered. This examination provided a degree of confidence in the way these specific parameters are handled in bearing analysis. A number of additional variables that are currently not directly included in

the calculation process are also open for consideration. These include variations created by operating parameters such as bearing speed, operating temperature, bearing design and type, and lubricant chemistry. The identification of a parametric relationship which needs to be included in the life estimation process could be of significant interest to bearing users and suppliers; and could provide a means of adding further confidence to the calculation of predicted bearing lives for future applications.

Accordingly, the objectives of Phase II of the extended program reported herein, and conducted under U. S. Army Contract No. DAAK50-78-C-0027 were established to be as follows.

1. Search the available data base for variations in operational parameters and examine the influence of these variables on bearing life.

2. Expand the data base on VIMVAR M-50 tool steel through tests aimed at assessing the influence of operational parameters, i.e., load, speed and lubricant type on bearing life.

3. Establish improved life modification factors for use in the calculation of rolling element bearing lives to account for variations in lubrication conditons and to compensate for life increases achieved through the utilization of VIMVAR M-50 tool steel.

These additional data will allow AVRADCOM to more accurately relate to the life potential of rolling contact bearings over a greater range of operational conditions occurring in Army helicopter service.

B. Statement of Work

The following work has been performed by the SKF Technology Services as agreed and outlined in Contract No. DAAK50-78-C-0027. The first part of this study deals with a statistical review and analysis of all available test data; and the second part is concerned with the expansion of the data base through the testing of full size rolling bearings manufactured from VIMVAR M-50 steel.

(1) Part I - Statistical Analysis

A search has been made of the available data base to establish variations in operational parameters, and where these variations were of sufficient quantity and variety, an examination of the influence of these variables on bearing life was conducted.

(2) Part II - Endurance Tests on Rolling Element Bearings

(a) Endurance Test Bearing Specimens and Test Schedule

The test vehicle used in this study is a 45 mm bore, 7309 VED angular contact ball bearing manufactured from aircraft certified Vacuum Induction Melt, Vacuum Arc Remelt (VIMVAR) M-50 tool steel. Fifty bearings were manufactured by SKF Technology Services for the purpose of determining the influence of operational parameters on endurance. Five groups of ten bearings have been run under four different sets of conditions and lubricated with a synthetic jet engine fluid conforming to MIL-L-23699. A fifth group was run under one of the same sets of test conditions using a synthetic jet engine lubricant conforming to MIL-L-7808H to assess the influence of lubricant chemistry on bearing life.

(b) Material and Lubrication Factor Determination

The endurance results of these five tests have been statistically integrated into the data base previously obtained and the expanded data analyzed to establish new values of the a_2 material factor and a_3 application factor.

II. M-50 LIFE DATA COLLECTION AND ANALYSIS

A. Data Collection

The initial analytical activity of this phase of the program was conducted using the preexisting data base. The assembly of the data was previously conducted under U. S. Army Contract No. DAAK50-77-C-0009 and has been described in detail in AVRADCOM Technical Report TR 79-35.

B. Data Search and Data Base Expansion

The data base consisted of the values of 13 distinct variables for each of 306 element and 53 bearing tests. During the conduct of Phase II, the values of four additional variables were determined by searching through the source material for each case in the life test data base. These were then added to the data base bringing to 17 the total number of variables recorded for each test. The supplementary variables are shaft or spindle speed in RPM, test temperature (°F), lubricant type and lubricant viscosity (cs).

Table 1 shows the data form used for recording and encoding the original 13 variables for each life test. The name by which each variable is identified in the output of the statistical programs used to process the data, is shown capitalized and underlined. The card columns into which each variable value is punched are given on the right hand side of the form.

Table 2 shows the supplementary data form used for recording and encoding the four additional variables for each life test.

In addition to the 17 independent variables recorded for each test, the values of five additional dependent variables were calculated as described in AVRADCOM TR 79-35 and used in the analysis effort.

TABLE 1

AVRADCOM M-50 STUDY

DATA FORM

	Card Col.
1. REF - Reference Number	1-4
2. TYPE - Tester Type 01) GE RC Rig 02) 4 ball tester 03) 5 ball tester 04) other element tester 10) single row deep groove ball bearing 11) angular contact ball bearing 12) cylindrical roller bearing 13) tapered roller bearing 14) spherical roller bearing	5-6
3. MAT - Material Type 1) Air Melt 2) CVM 3) Multiple CVM 4) VIMVAR 5) Other	7
4. PROC - Material Processing 1) Standard 2) Ausformed 3) Powder	8
5. STRESS - Max. Contact Stress on Test Element (ksi)	9-11
6. SIZE - Test Element Size Test specimen radius (in.) for element tests Bore size (in.) for rolling bearings	12-16
7. H - Film Thickness (microinch)	17-20
8. SIGMA - Composite Surface Roughness (microinch)	21-23
9. LIOTH - Theoretical L_{10} Life (millions of revolutions)	24-30
10. N - Sample Size	31-33
11. R - Number of Failures	34-36
12. LIOEX - Maximum Likelihood Experimental L_{10} Estimate (million of revolutions) (No Bias Correction)	37-43
13. BETA - Experimental Weibull Slope Estimate	44-47

TABLE 2

AVRADCOM M-50 STUDY

DATA FORM SUPPLEMENT

Card Col.

14. SPEED - Spindle Speed (RPM) 50-54

15. TEMP - Test Temperature (°F) 55-57

16. LUBE - Test Lubricant Type

01) MIL-L-23699
02) MIL-L-7808
03) Paraffinic Mineral Oil
04) Naphthenic Mineral Oil
05) Tetra Ester
06) Grease
07) Other Mineral Oil
08) Other Synthetic Oil

58-59

17. VIS - Viscosity (cs) 60-63

These dependent variables are identified as follows:

H/SIG = H ÷ SIGMA, the lubricant film parameter

FILFAC = The lubricant film life multiplication factor. FILFAC is computed as a function of H/SIG using the following piecewise approximation to the ASME curve presented in [3].

FILFAC	H/SIG
0.2	< 0.6
0.75(H/SIG)0.25	0.6 to 1.0
1.75(H/SIG)-1.2	1.0 to 2.0
0.114(H/SIG)+1.97	2.0 to 9.0
3.0	≥ 9

MATFAC = LIOEX/(LIOTH x FILFAC) ; the calculated material factor for a given test i.e. the value by which the classically calculated theoretical L_{10} life must be multiplied to account for the fatigue resistance of the given material.

LOGMAT = LN (MATFAC), the natural logarithm of MATFAC. As shown in AVRADCOM TR 79-35 the distribution of MATFAC is highly skewed to the right, while its logarithmic transformation LOGMAT is very nearly normally distributed.

WTFAC = R (LOGMAT), the value of LOGMAT weighted by the number of failures in each test was also calculated.

[3] Bamberger, E. N., Harris, T. A., Kacmarsky, W. M. Moyer, C. A., Parker, R. J., Sherlock, J. J., and Zaretsky, E. V., Life Adjustment Factors for Ball and Roller Bearings, The American Society of Mechanical Engineers, 1971.

It was found in PHASE I that WTFAC did not improve the precision of interval estimates of the material factor and so was not used. It was nevertheless calculated in the PHASE II data processing since the program was not altered to delete this function.

Appendix A contains a summary of the 22 variables accumulated for each of the 306 element tests. Appendix B summarizes the values for the expanded data base of 58 bearing tests i.e. including the five groups tested during this program. These Appendixes were generated using program BMDP1D of the computer program package BMDP (August 1977 Revision) developed at the Health Sciences Computing Facility, UCLA [4].

[4] The Health Sciences Computing Facility is sponsored by N I H Special Research Resources Grant RR-3.

C. Statistical Summary

Table 3 is a summary produced by program BMDP1D giving for each of the 22 variables among the 306 element tests.

(1) the mean or arithmetic average, $\bar{X}$

(2) the standard deviation S

(3) the standard error of the mean ($S/\sqrt{306}$)

(4) the coefficient of variation $S/\bar{X}$

(5) the smallest and largest values

(6) the smallest and largest values standardized by the standard deviation. This is termed Z - score in Table 3.

(7) the range, i.e. the difference between the largest and smallest variable value, and

(8) the frequency count for each variable.

Table 4 is the corresponding summary for the bearing test data. The addition of the five VIMVAR tests has had a very minor effect on the bearing data as a whole. The mean value of LOGMAT has increased from 1.14 to 1.15 while its standard deviation has decreased from 1.57 to 1.53. (The new tests have a substantial impact on the VIMVAR M-50 subset of the data base however).

The smallest value column in Table 4 reveals the presence of two cases for which the stress was unknown and hence recorded as zero, and two tests for which no failures were obtained.

Table 5 is a 2-way contingency table prepared using program BMDP2F showing how the 364 data base entries are distributed over lubricant and material types. 76% of the tests were run using MIL-L-23699 lubricant and 14% were run using MIL-L-7808 lubricant. There were a total of 16 tests with VIMVAR M-50 steel. For the bulk of the tests (87%) the material was CVM. Table 6 is a 2 way table for tester type and material. It shows that the element tests (type ≤ 4.0) are dominated by the Rc rig. The bearing tests are dominated by single row deep groove and angular contacts in approximately equal proportions. 10 of the 16 VIMVAR

TABLE 3

STATISTICAL SUMMARY
306 ELEMENT TESTS

VARIABLE NO.	NAME	MEAN	STANDARD DEVIATION	ST.ERR. OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE	TOTAL FREQUENCY
1	REF	2118.826	2202.022	125.9512	1.03926	1002.000	-0.51	7863.000	2.61	6861.000	306
2	TYPE	1.222	0.744	0.0425	0.60885	1.000	-0.30	4.000	3.73	3.000	306
3	MAT	2.039	0.484	0.0277	0.23748	1.000	-2.15	5.000	6.11	4.000	306
4	PROC	1.020	0.161	0.0092	0.15767	1.000	-0.12	3.000	12.32	2.000	306
5	STRESS	686.740	78.405	4.4821	0.11416	30.000	-8.38	800.000	1.44	770.000	306
6	SIZE	0.388	0.096	0.0055	0.24808	0.013	-3.90	1.125	7.66	1.112	306
7	H	7.446	7.935	0.4536	1.01140	0.300	-0.95	25.600	2.24	25.300	306
8	SIGMA	11.407	2.506	0.1432	0.21966	0.700	-4.27	17.000	2.23	16.300	306
9	LIDTH	63.068	658.922	37.6690	10.44779	0.210	-0.10	8046.000	12.12	8045.789	306
10	\	9.330	7.804	0.4464	0.83690	2.000	-0.94	72.000	8.03	70.000	306
11	R	8.572	5.774	0.3301	0.67362	2.000	-1.14	72.000	10.98	70.000	306
12	LIDEX	5.819	20.243	1.1572	3.47895	0.210	-0.28	315.000	15.27	314.790	306
13	BETA	4.863	2.998	0.1714	0.61659	0.510	-1.45	20.900	5.35	20.390	306
14	SPEED	12096.258	1469.173	83.9774	0.12146	3400.000	-5.92	12500.000	0.27	9100.000	306
15	TEMP	315.654	230.477	13.1784	0.73142	77.000	-1.03	600.000	1.23	523.000	306
16	LOSE	1.225	0.724	0.0414	0.59044	1.000	-0.32	7.000	7.97	6.000	306
17	VIS	20.736	27.702	1.5836	1.33593	0.720	-0.72	150.000	4.67	149.280	306
18	H/SIG	1.248	3.716	0.2124	2.88466	0.025	-0.34	25.125	6.42	25.100	306
19	FILFAC	0.701	0.652	0.0373	0.92901	0.200	-0.77	3.000	3.53	2.800	306
20	MATFAC	10.643	14.189	0.8112	1.33324	0.006	-0.75	130.791	8.47	130.784	306
21	WIFAC	14.566	13.133	0.7508	0.90163	-40.848	-4.22	138.977	9.47	179.824	306
22	LOGMAT	1.831	1.180	0.0675	0.64467	-5.039	-5.82	4.874	2.58	9.913	306

TABLE 4

STATISTICAL SUMMARY
58 BEARING TESTS

VARIABLE NO.	NAME	MEAN	STANDARD DEVIATION	ST.ERR. OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE	TOTAL FREQUENCY
1	REF	7066.845	637.506	83.7086	0.09021	5811.000	-1.97	7925.000	1.35	2114.000	58
2	TYPE	10.776	0.918	0.1206	0.08524	10.000	-0.84	14.000	3.51	4.000	58
3	MAT	2.448	1.127	0.1479	0.46016	-0.0	-2.17	5.000	2.27	5.000	58
4	PROC	1.052	0.223	0.0293	0.21242	1.000	-0.23	2.000	4.24	1.000	58
5	STRESS	346.032	147.146	19.3213	0.42524	0.0	-2.35	670.000	2.20	670.000	58
6	SIZE	2.640	1.340	0.1760	0.50775	1.177	-1.09	5.512	2.14	4.335	58
7	H	17.945	18.248	2.3960	1.01689	1.000	-0.93	101.600	4.58	100.600	58
8	SIGMA	5.402	2.639	0.3465	0.4 [illegible]12	1.800	-1.55	11.700	2.20	9.900	58
9	LIOTH	19.006	31.442	4.1311	1.65509	1.330	-0.56	209.000	6.04	207.670	58
10	N	21.155	14.923	1.9593	0.70567	4.000	-1.16	100.000	5.32	96.000	58
11	P	10.241	6.927	1.1722	0.67648	0.0	-1.15	30.000	2.21	30.000	58
12	LIOLX	187.378	466.394	61.2496	2.48905	0.720	-0.40	2700.000	5.39	2699.280	58
13	BETA	2.088	3.347	0.4394	1.60332	0.490	-0.48	20.370	5.46	19.880	56
14	SPEED	10693.227	11659.047	1530.9877	1.09042	244.300	-0.90	65000.000	4.66	64757.000	58
15	TEMP	254.239	143.371	18.8256	0.56392	77.000	-1.24	600.000	2.41	523.000	58
16	LUBE	2.414	1.364	0.1791	0.56514	1.000	-1.04	6.000	2.63	5.000	58
17	VIS	9.579	10.132	1.3301	1.05765	0.010	-0.85	60.000	4.98	59.990	58
18	H/SIG	3.356	2.691	0.3533	0.80183	0.152	-1.19	11.416	2.99	11.264	58
19	FILFAC	1.840	0.979	0.1286	0.53219	0.200	-1.67	3.000	1.18	2.800	58
20	MATFAC	6.859	14.734	1.9347	1.48146	0.111	-0.59	73.634	4.41	73.523	58
21	HTFAC	11.505	25.684	3.3724	2.23245	-59.922	-2.78	128.973	4.57	188.895	58
22	LOGMAT	1.145	1.533	0.2013	1.33882	-2.199	-2.18	4.299	2.06	6.499	58

TABLE 5

2-WAY CONTINGENCY TABLE FOR LUBRICANT MIL-L-23699
AND MATERIAL

TABLE NO. 1 LUBE (VAR 16) VS MAT (VAR 3)

CELL FREQUENCY COUNTS

			MAT (VAR 3)					
			Air Melt	CVM	Mult CVM	VimVar	Other	
	EQ./EQ.	0.00	1.00	2.00	3.00	4.00	5.00	TOTAL
LUBE 23699	1.00	0	1	261	0	8	1	271
(VAR 16) 7808	2.00	2	12	28	0	5	4	51
Par Min	3.00	0	3	16	4	0	2	25
Napth Min	4.00	0	0	0	0	1	0	1
Tetra Ester	5.00	0	0	2	1	2	0	5
Grease	6.00	0	0	2	0	0	0	2
Other Min	7.00	0	0	3	0	0	0	3
	TOTAL	2	16	318	5	16	7	364

CHISQUARE	PROBABILITY	D.F.
196.66	0.0000	30

AL79T027

TABLE 6

2-WAY CONTINGENCY TABLE FOR TESTER TYPE AND MATERIAL

TABLE NO. 1 TYPE (VAR 2) VS MAT (VAR 3)

CELL FREQUENCY COUNTS

			MAT (VAR 3)					
			Air Melt	CVM	Mult CVM	VimVar	Other	
		EQ./EQ.	0.00	1.00	2.00	3.00	4.00	5.00	TOTAL
TYPE (VAR 2)	RC Rig	1.00	0	12	262	0	1	4	279
	4 Ball	2.00	0	0	1	0	2	0	3
	5 Ball	3.00	0	0	6	0	1	0	7
	Other Elem	4.00	0	0	15	0	2	0	17
	D.G. Ball Brg.	10.0	0	3	14	5	1	3	26
	Ang Ball Brg.	11.0	2	0	12	0	9	0	23
	Cyl Roll Brg.	12.0	0	1	6	0	0	0	7
	Sphere Roll Brg.	14.0	0	0	2	0	0	0	2
	TOTAL		2	16	318	5	16	7	364

CHISQUARE	PROBABILITY	D.F.
228.53	0.0	35

M-50 steel tests were performed on bearings, 9 of which were angular contact. Two angular contact tests could not be identified by material type and are shown having MAT=0.

Table 7 is a two way table for tester type and lubricant. Of the bearing tests, 19 were run with MIL-L-23699. 12 with MIL-L-7808 and 20 with paraffinic numeral oil.

TABLE 7

2-WAY CONTINGENCY TABLE FOR LUBRICANT AND TESTER TYPE

TABLE NO. 1 TYPE (VAR 2) VS LUBE (VAR 16)

CELL FREQUENCY COUNTS

			LUBE (VAR 16)							
			23699	7808	Par Min	Napth Min	Tetra Ester	Grease	Other Min	
		EQ./EQ.	1.00	2.00	3.00	4.00	5.00	6.00	7.00	TOTAL
TYPE (VAR 2)	RC Rig	1.00	254	25	0	0	0	0	0	279
	4 Ball	2.00	3	0	0	0	0	0	0	3
	5 Ball	3.00	0	0	3	1	0	0	3	7
	Other Elem	4.00	1	14	2	0	0	0	0	17
	DG Ball Brg	10.0	5	7	11	0	1	2	0	26
	Ang Ball Brg	11.0	6	4	9	0	4	0	0	23
	Cyl Ball Brg	12.0	7	0	0	0	0	0	0	7
	Sphere Ball Brg	14.0	1	1	0	0	0	0	0	2
	TOTAL		277	51	25	1	5	2	3	364

CHISQUARE	PROBABILITY	D.F.
507.95	0.0	42

D. Effects of Speed, Temperature and Viscosity

The film factor reflects the effect of speed, temperature and viscosity inasmuch as these variables determine the film thickness and hence the film factor. To determine whether any additional effect of these variables was present due to systematic errors in the models used for calculation of the theoretical life, the film thickness and the film factor values, bivariate plots were generated for LOGMAT vs. speed, temperature, and viscosity. The Weibull shape parameter, BETA assumed to be invariant in life calculations was also plotted against these same variables.

Figures 1 to 6 show the plots for the bearing tests. The calculated correlation coefficient (COR) between each pair of variables is printed below each plot. No significant effect is apparent except in the plot of BETA against speed. The relatively high correlation coefficient calculated here, however, is almost exclusively due to a single high speed test having a very high Weibull shape parameter. Inasmuch as this value is well outside the range of usual experience and was, as it proved, based on a group with only two failed bearings, it is highly likely to be spurious. Without this point, the data follow no obvious trend with speed, thus it would be concluded that all these variables are adequately considered in the calculation process.

Figures 7 to 12 are the corresponding plots for the element tests. Because of the greater number of element tests, correlation coefficients higher in absolute value than 0.13 are likely to be an indication of a true relationship between the variables. (More exactly with 306 paired variables, a correlation coefficient greater in absolute value than 0.13 will occur due to chance alone with a probability of 5%). Thus, all of the plots in Figures 7 to 12 show evidence of real correlation, eg. a dependent relationship existing between the two variables.

Both LOGMAT and BETA increase with speed and temperature and decrease with viscosity. Because of correlations between the variables, it is difficult to attempt a causal explanation. For example, a true viscosity effect may not exist. The apparent viscosity effect may only reflect the temperature effect inasmuch as temperature and viscosity vary inversely. By the same token, temperature and stress are likely to be correlative. In the Phase I effort, LOGMAT was found to increase with stress.

The scatter plots simply imply a model discrepancy in the treatment of element test configurations. Further analysis would have to be performed to resolve how the models are discrepant.

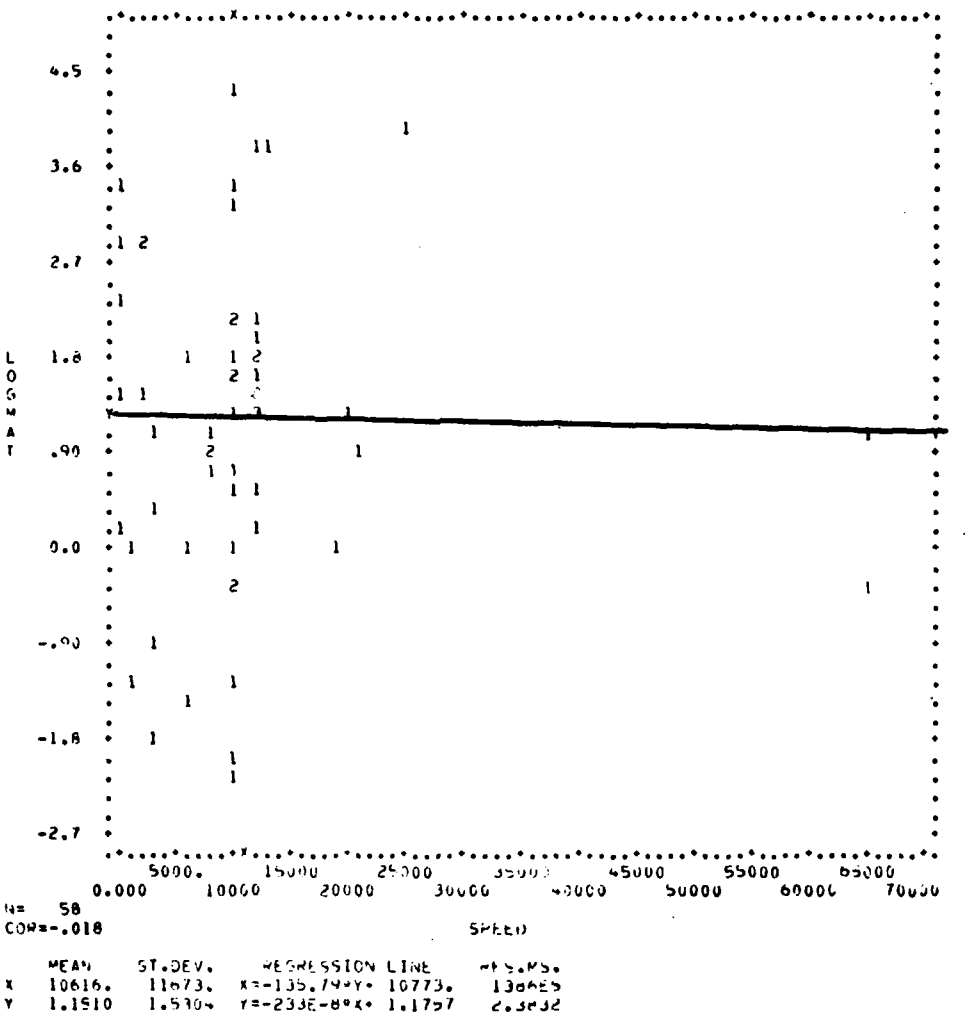


FIGURE 1. LOGMAT VS SPEED - BEARING TESTS

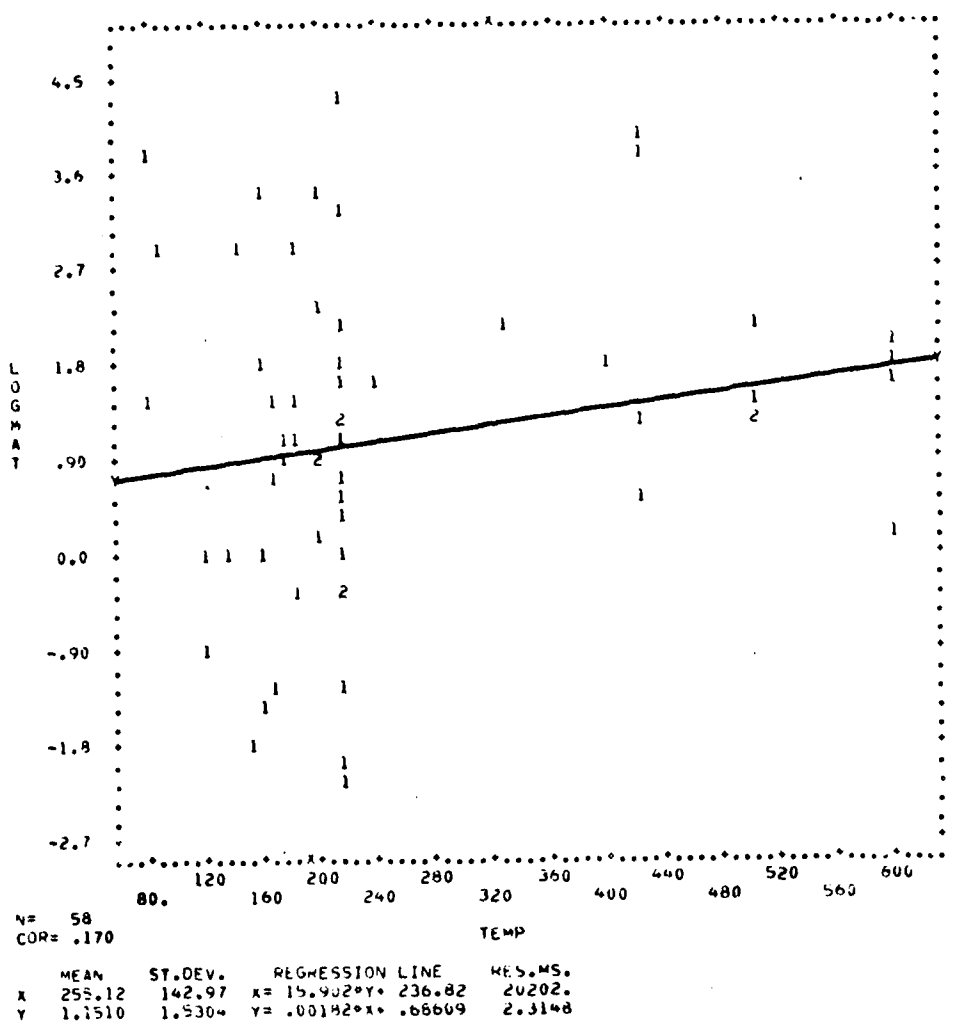


FIGURE 2. LOGMAT VS TEMP. - BEARING TESTS

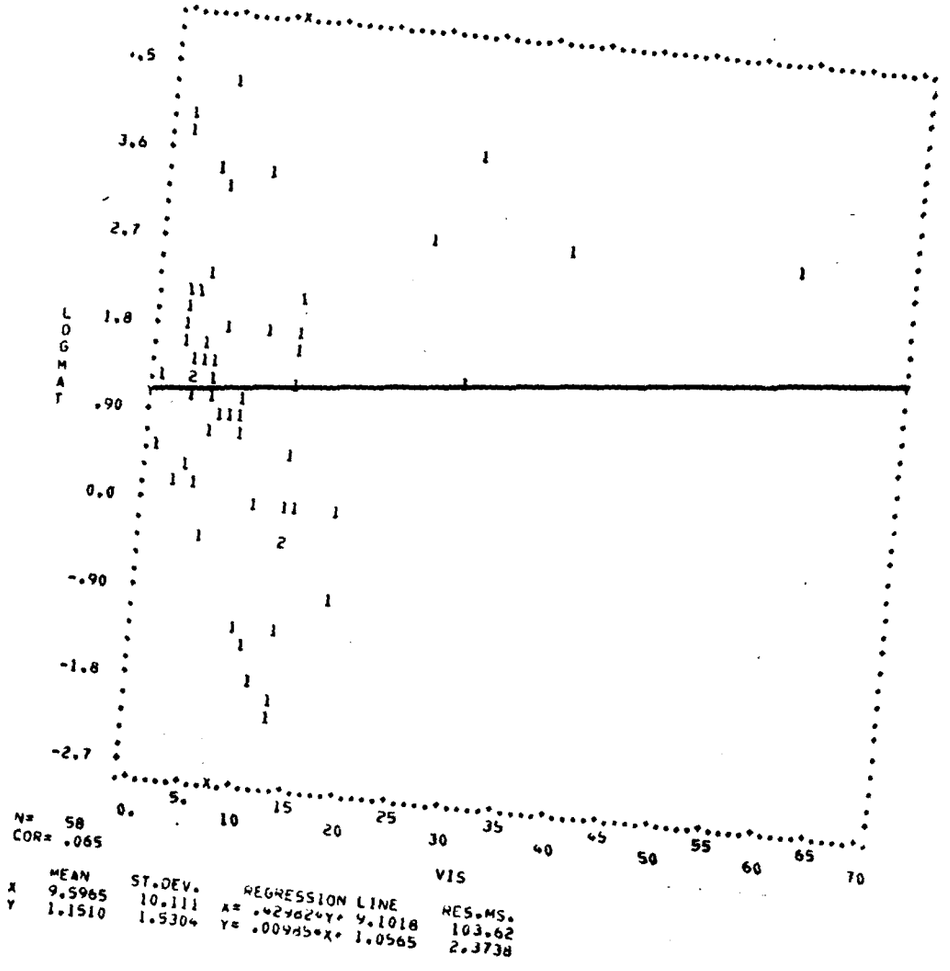
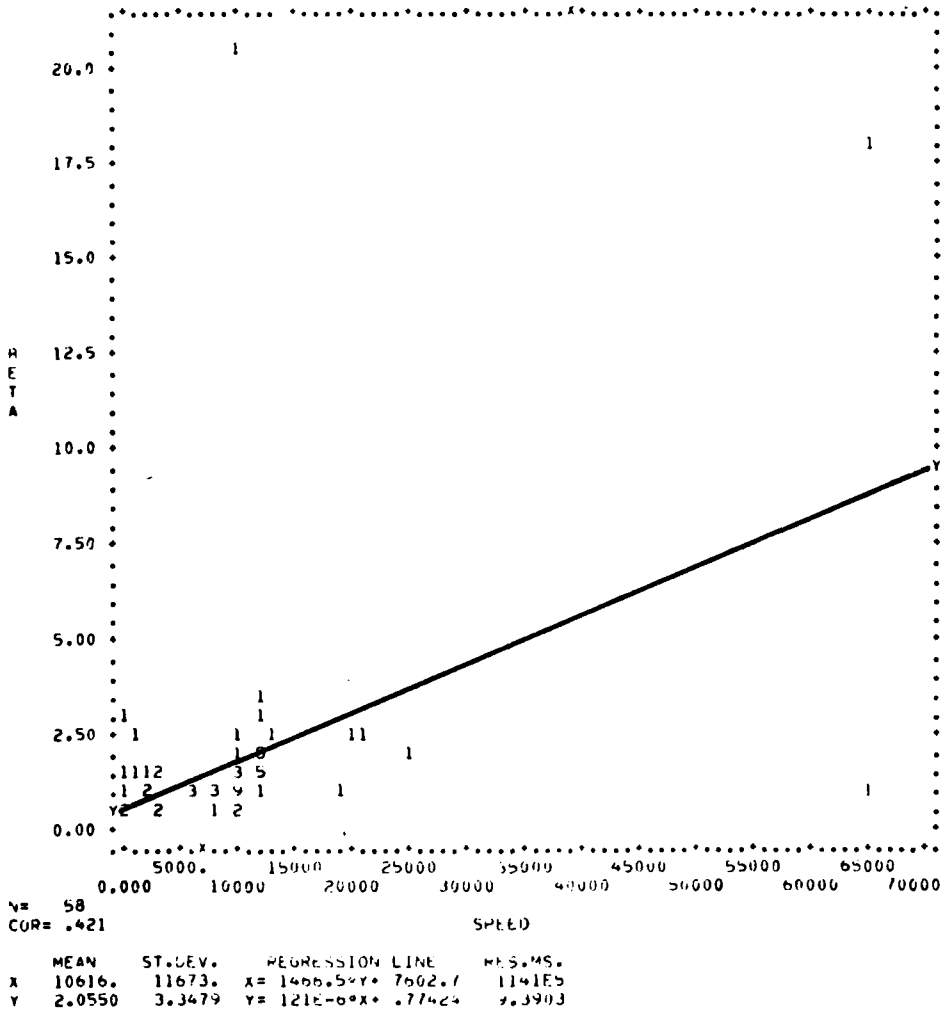


FIGURE 3. LOGMAT VS VISCOSITY - BEARING TESTS



N= 58
COR= .421

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	10616.	11673.	X= 1466.5*Y+ 7602.7	1141E5
Y	2.0550	3.3479	Y= 121E-6*X+ .77424	9.3903

FIGURE 4. BETA VS SPEED - BEARING TESTS

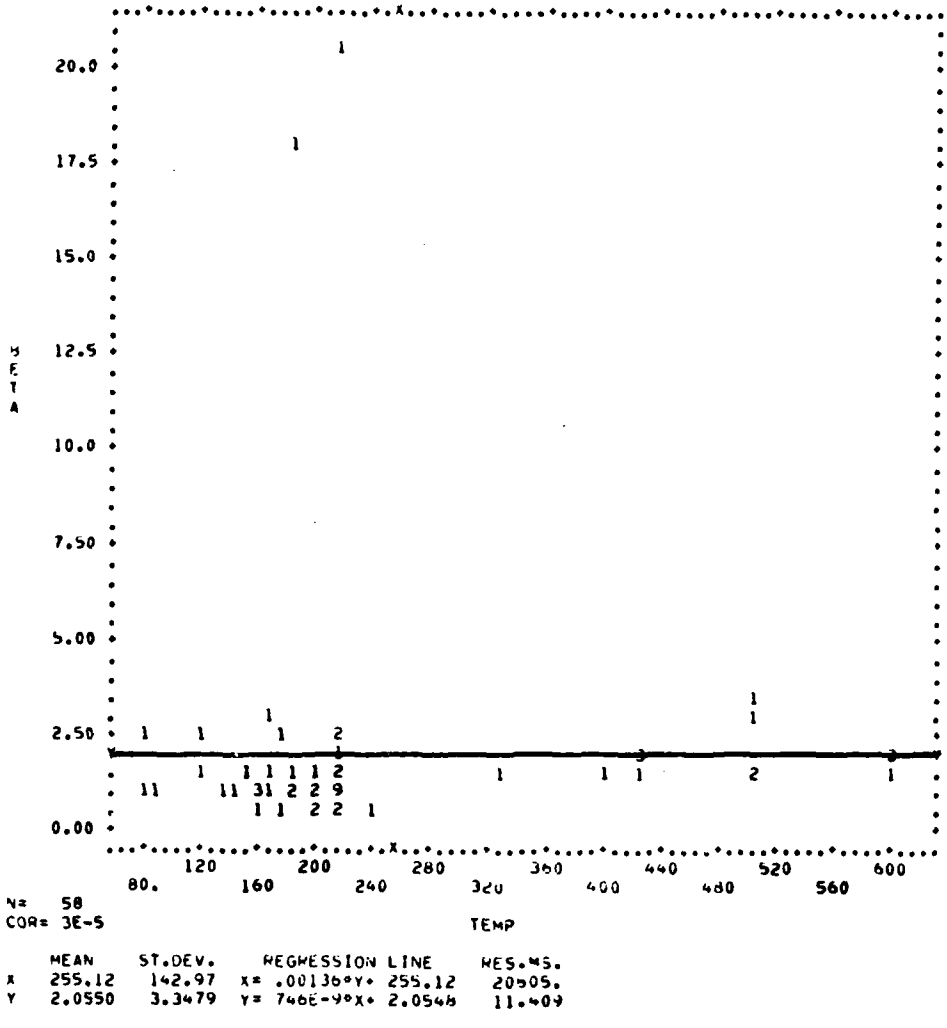


FIGURE 5. BETA VS TEMP. - BEARING TESTS

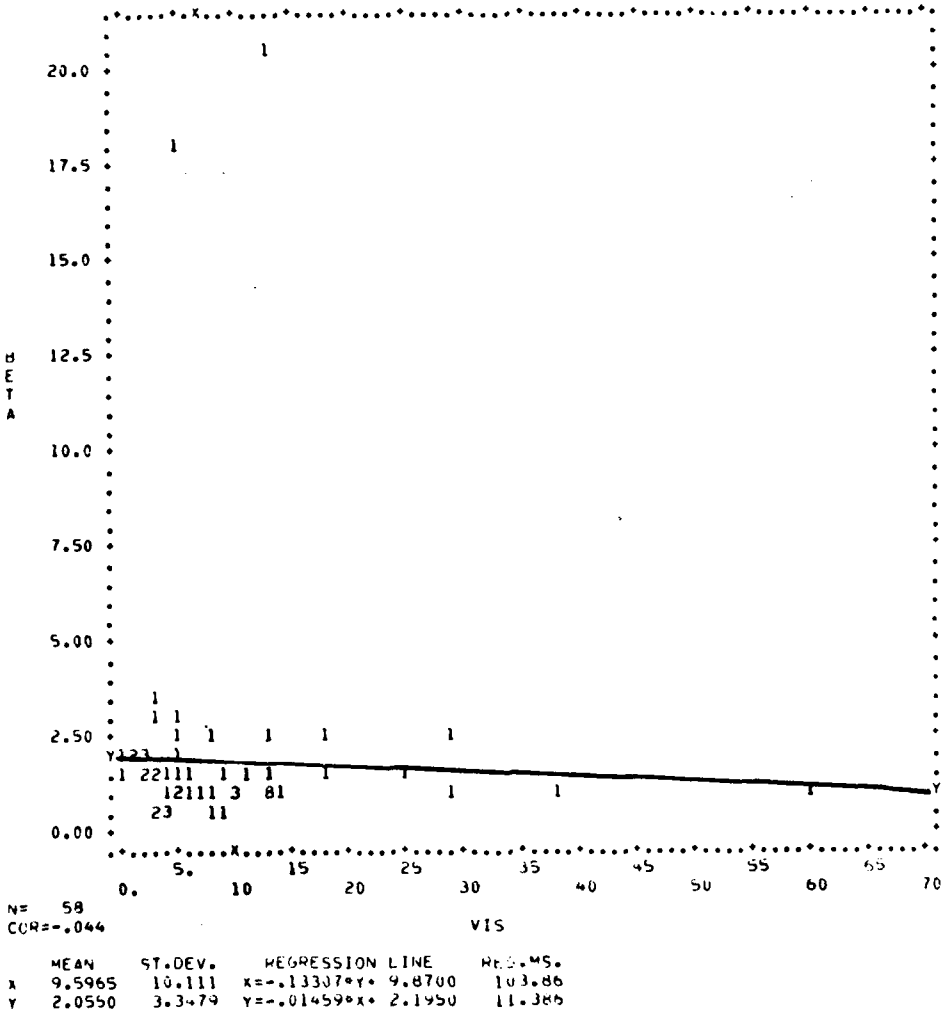


FIGURE 6. BETA VS VISCOSITY - BEARING TESTS

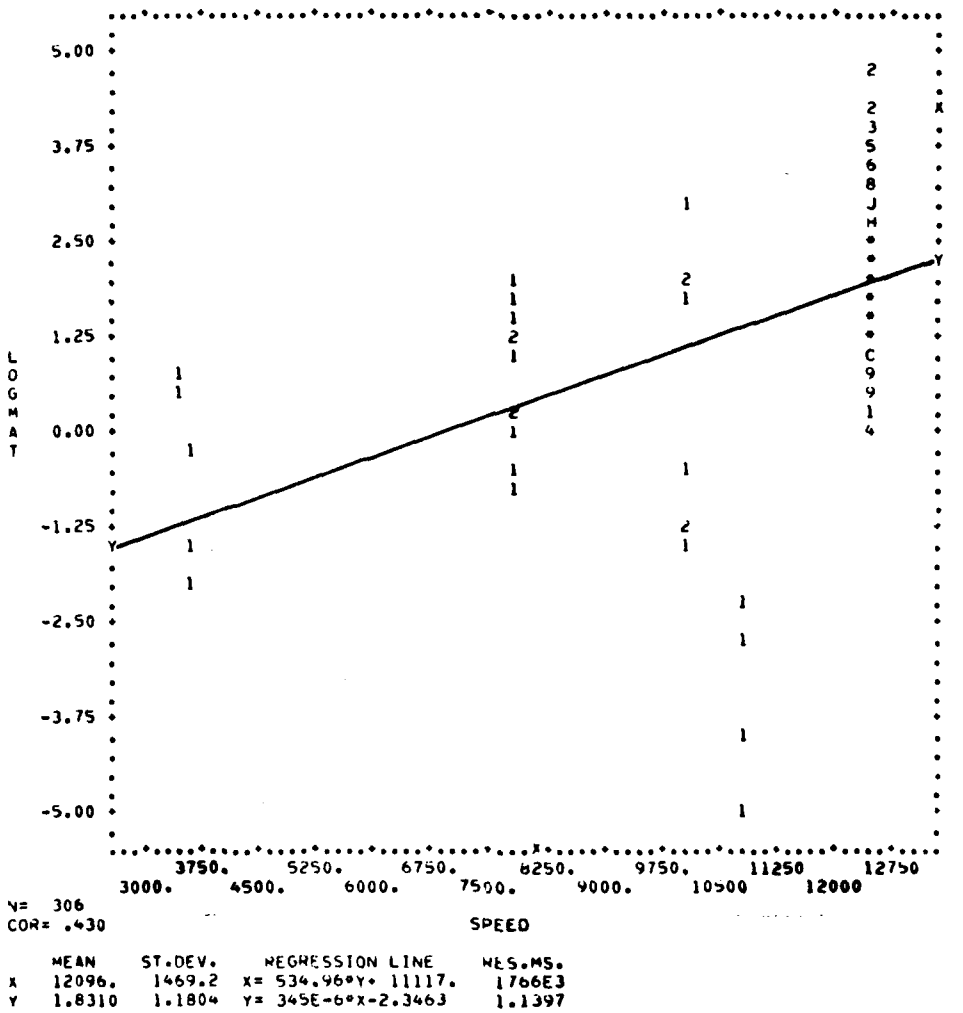


FIGURE 7. LOGMAT VS SPEED - ELEMENT TESTS

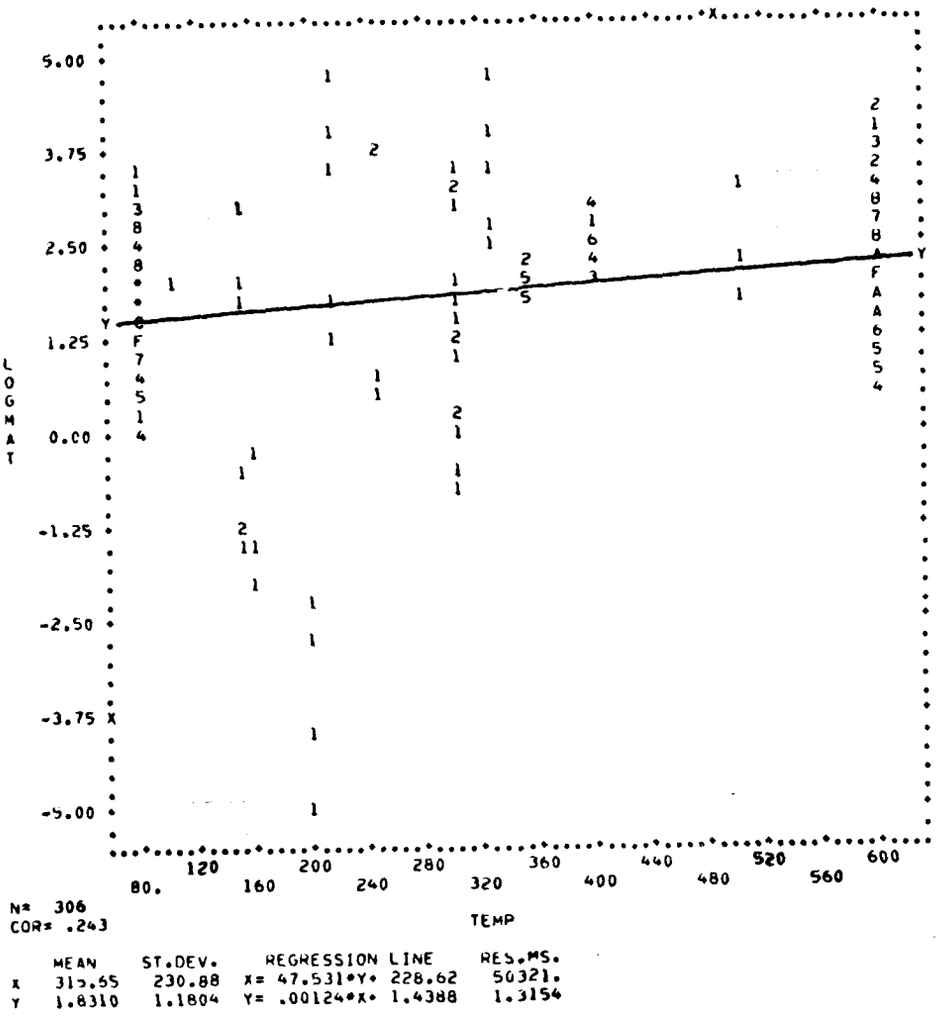
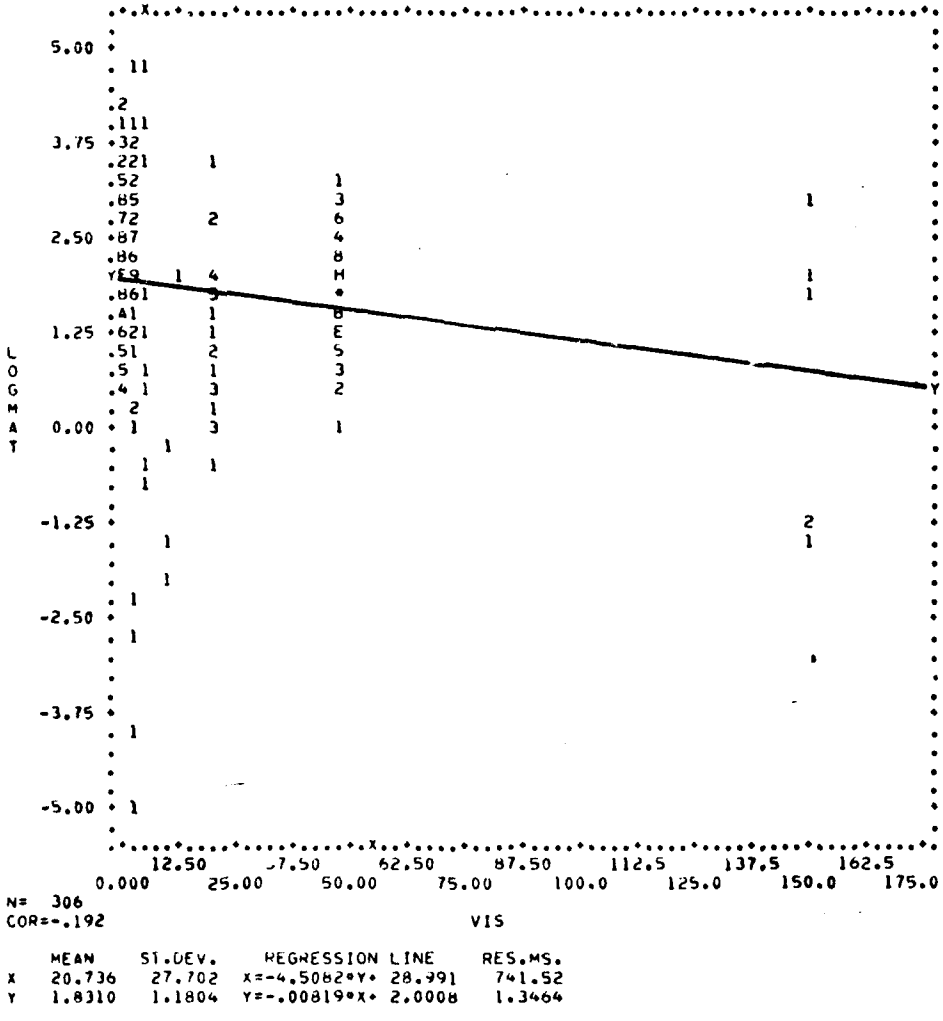


FIGURE 8. LOGMAT VS TEMP - ELEMENT TESTS



	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	20.736	27.702	X=-4.5082*Y+ 28.991	741.52
Y	1.8310	1.1804	Y=-.00819*X+ 2.0008	1.3464

FIGURE 9. LOGMAT VS VISCOSITY - ELEMENT TESTS

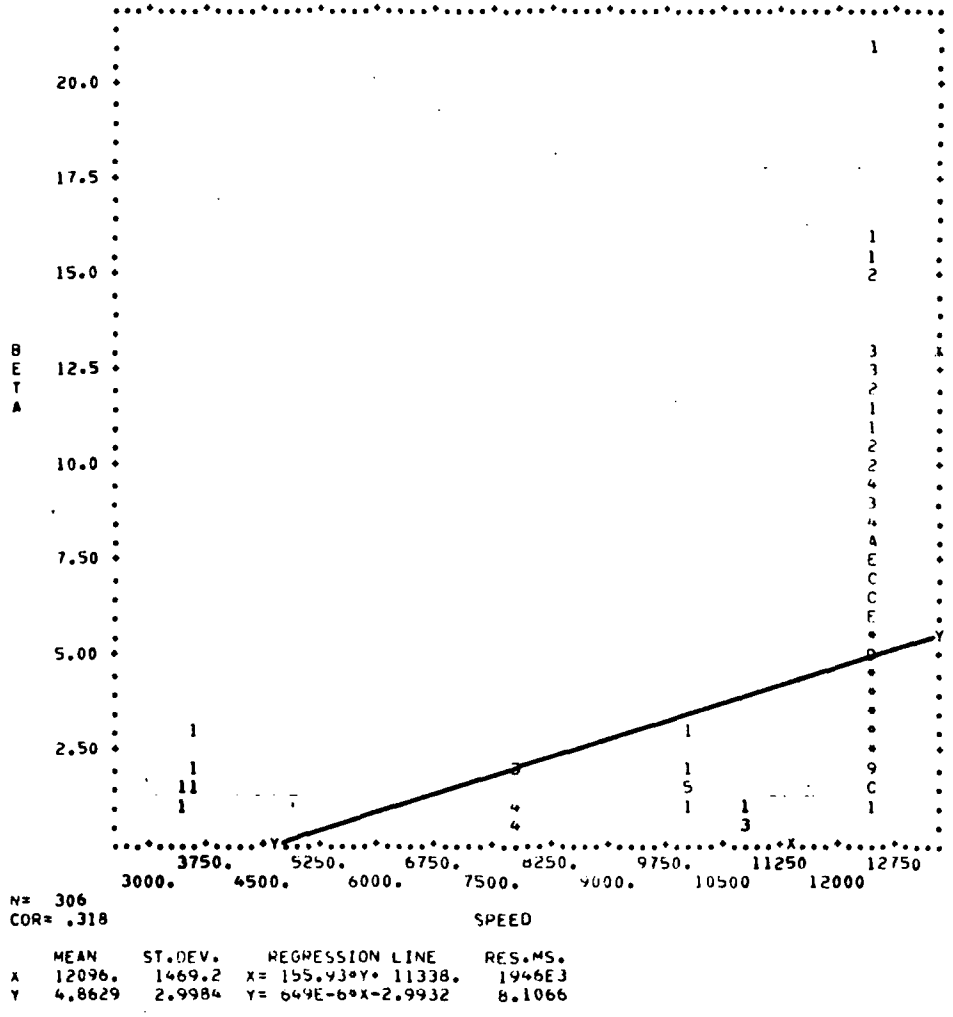


FIGURE 10. BETA VS SPEED - ELEMENT TESTS

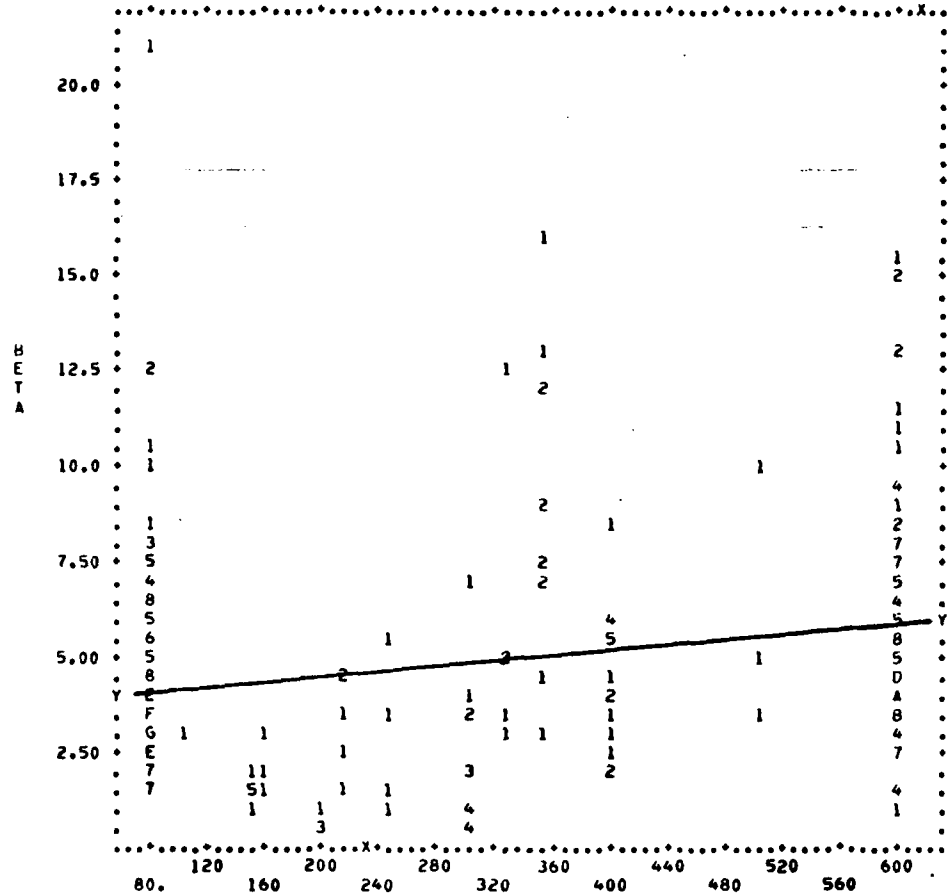
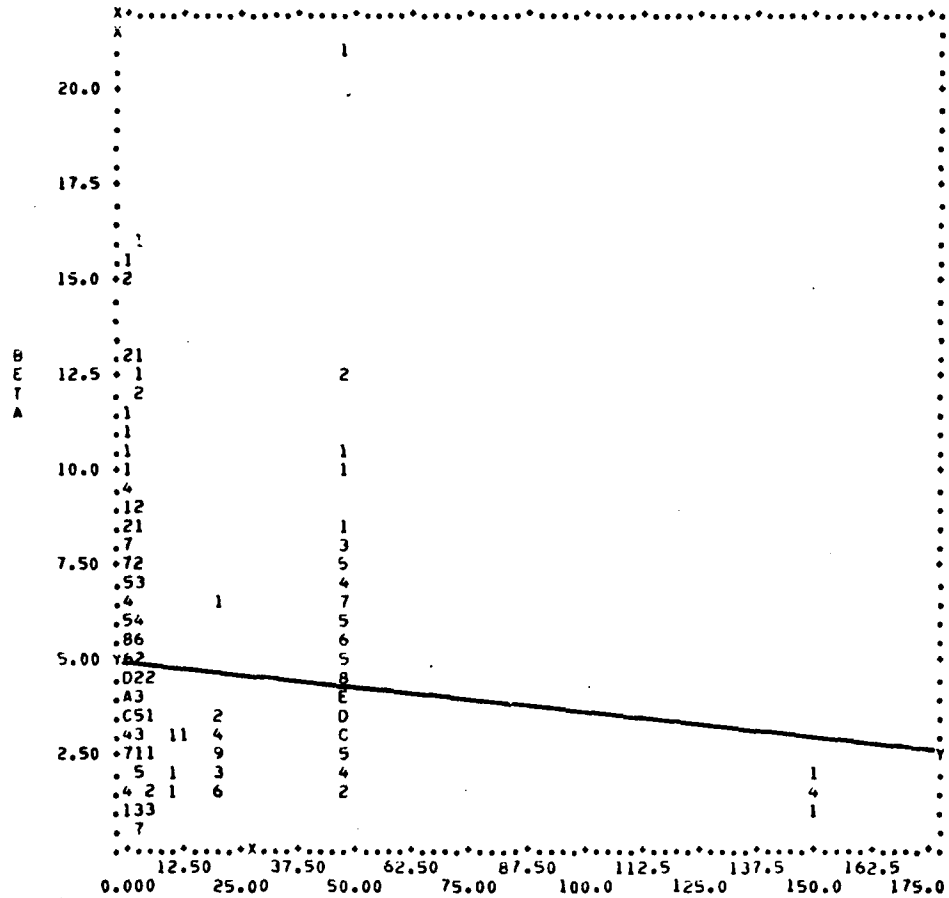


FIGURE 11. BETA VS TEMP. - ELEMENT TESTS



N= 306
COR=-.149

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	20.736	27.702	X=-1.3764*Y+ 27.429	752.84
Y	4.8629	2.9984	Y=-.01612*X+ 5.1973	8.8199

FIGURE 12. BETA VS VISCOSITY - ELEMENT TESTS

E. Effect of Lubricant Type

As noted, the bulk of the tests were conducted using MIL-L-23699 and MIL-L-7808 lubricants. An attempt has been made to determine whether the data suggest a difference in life performance of these two lubricants. Since a difference between element and bearing tests has already been established, this assessment was conducted separately for elements and bearings.

The mean and standard deviation of LOGMAT and the total number of deviations for the four subsets of data corresponding to partitioning by lubricant type and test type are tabled below along with the frequency of occurrence of each subset.

Partition	Mean Value of LOGMAT	STD. DEV. of LOGMAT	No. of Cases
MIL-L-23699-Bearings	0.946	1.725	19
MIL-L-7808-Bearings	1.428	1.236	12
MIL-L-23699-Elements	2.055	0.890	258
MIL-L-7808-Elements	0.689	1.748	39

Testing the variables by means of an F ratio test statistic, there is found to be no significant difference between the variance for the bearings, but an overwhelming difference for the element tests. The MIL-L-7808 tests are noted to have a standard deviation quite comparable to the bearing tests.

There is also a substantial difference in the mean value of LOGMAT between the element tests with the mean for the MIL-L-23699 tests being substantially higher.

It is not possible to conclude that this difference is due to a difference in the oils, however, because in unbalanced data of this type, there can be confounding with other influential variables. In particular, inasmuch as 254 of the 258 element tests on MIL-L-23699 came from a single source, differences in test conditions or techniques between this and the other sources of element data could account for the observed differences.

A "t" test showed no significant difference between the two lubricants within the bearing tests.

This would suggest that the use of the different lubricants produce no effect on bearing life other than that which is accounted for by using the lubricant film factor.

F. VIMVAR M-50 Material

The mean and standard deviations of LOGMAT for the subset of VIMVAR material tests are as follows.

	Mean Value LOGMAT	STD. DEV. LOGMAT	No. of Tests
VIMVAR M-50 Bearings	1.731	1.807	10
VIMVAR M-50 Elements	0.235	1.280	6

90% confidence intervals for MATFAC computed as in AVRADCOM TR 79-35 are:

Bearings: $2.21 < \text{MATFAC} < 14.5$

Elements: $0.0 < \text{MATFAC} < 3.0$

Point estimates of the material factor for VIMVAR M-50 are:

Bearings: $\text{MATFAC} = \exp(1.731) = 5.65$

Elements: $\text{MATFAC} = \exp(0.235) = 1.26$

The estimated VIMVAR M-50 material factor for bearings is larger than the material factor of 3.55 deduced from the tests based on all bearings. Inasmuch as 3.55 falls within the uncertainty interval for the VIMVAR tests, there is insufficient evidence to claim a superiority for VIMVAR M-50 based on the data accumulated so far.

The VIMVAR M-50 element tests give a significantly lower value of MATFAC than the element data as a whole. As with the MIL-L-7808 element tests the VIMVAR M-50 set exhibits more scatter than the element data. Again the observed differences may not indicate an inferiority of VIMVAR M-50 elements, but a confounding of material with other factors due to the fact that the element data set is numerically dominated by tests from a single source.

G. Effects of Bearing Configuration

The data base contains a limited amount of life data collected on varying bearing configurations so it was not warranted to conduct a detailed comparison of apparent material factor by specific bearing type. In lieu of this, the data were combined to provide a comparison of results obtained from point contacts, eg ball and angular contact bearings, versus line contacts, eg cylindrical, taper and spherical roller bearings.

The mean and standard deviation of LOGMAT for each set of data are listed below:

	Line Contact	Point Contact
Mean	0.324	1.303
Standard deviation	1.624	1.480
Number of tests	9	49

The values of the calculated standard deviations do not differ significantly. However, a "t" test conducted on the data establishes that the difference in the mean values are significant at the 5% level.

This result is somewhat surprising since the line contact bearings exhibited the lower factor. In the tests conducted in Phase I, the cylindrical bearings exhibited a large apparent material factor, $a_2 = 32.8$, suggesting that these bearings are underrated. This effect has also been consistently observed over the years in endurance tests conducted on standard steels, where line contact bearings have provided experimental lives significantly in excess of theoretical.

An examination of the individual data points comprising the line contact results revealed that 2/3 of the tests were conducted prior to 1968 and had yielded relatively low theoretical/experimental life ratios. Thus, it would seem that the comparison contains a biasing effect produced by a high concentration of tests on relatively old M50 material. On this basis, it is considered that the data currently available are insufficient to allow an adequate comparison of the effects of design type, even when simplified to consider only line and point contacts.

H. Principal Statistical Results

1. The material factor for bearings exhibits no significant dependence on lubricant type, temperature, speed or viscosity apart from that which is accounted for in the lubricant film factor. The material factor for elements varies with all of these factors.

2. Apparent differences in the mean and scatter of the material factor between MIL-L-23699 and MIL-L-7808H lubricants exhibited in the element tests could conceivably be due to differences in test technique and/or conditions in as much as most of the MIL-L-23699 element data came from a single source.

3. The VIMVAR M-50 data for bearings give an estimated material factor of 5.65. Statistically, this value is not significantly greater than the estimated factor of 3.55 previously deduced for all M-50 bearings. Precisely interpreted, these results state that the lower value should be utilized. However, recognizing that the data base is skewed by a concentration of older data and that technically VIMVAR melting is superior to CVM, the use of an a_2 factor equal to 5 seems justified.

4. The factor for VIMVAR M-50 elements is lower and more variable than found in the element data base as a whole. Again, this may reflect the dominance of the element data base by long lived tests with high average Weibull slopes (low scatter).

5. The average values of H/SIG and FILFAC based on the test results obtained on ten groups of bearings manufactured from VIMVAR M-50 tool steel are 2.77 and 1.94 respectively.

III. ENDURANCE TEST DETAILS

A. Test Equipment

All tests were conducted on SKF R-2 Endurance Test Machines which have been developed over a period of years for the evaluation of full size rolling bearings. Basically, these test machines consist of a horizontal arbor of symmetrical configuration, as shown in Figure 13, supported on either side of its center by two cylindrical roller bearings located in pillow blocks fastened to a machine base. The 7309 VED angular contact test bearings are located on each end of this arbor in independent housings to minimize interactions between the test specimens. They are axially loaded by means of a tie rod passing through a clearance hole in the center of the arbor. A strain gaged bolt on one end of the tie rod measures the amount of thrust load applied as the loading nut on the other end of the rod is turned. A centrally located pulley on the machine arbor rotates the inner rings at the desired speed.

Alignment of the test bearing outer ring with respect to the inner ring and arbor is maintained by means of a small cylindrical roller bearing located at the end of the machine arbor.

The test bearing operating temperature is measured by a spring loaded thermocouple contacting the outer ring. A Test Floor Control System containing a Data General Nova 800 Computer System as a central processing unit monitors the output from this transducer. The same computer system measures the applied thrust load.

Bearing failures are detected by a vibration sensitive transducer which is set at the beginning of each run. The vibraswitch stops the test machine when the general vibration level increases significantly over the original magnitude, indicative of a spall on a bearing component.

All bearings were run to failure or to an established time up life unless the test was suspended for mechanical reasons, i.e. failure of test machine hardware.

Each bearing was lubricated from a common oil supply system containing synthetic lubricating fluid conforming to the government specification noted under the test conditions. The oil was jetted into the test bearing housing and aimed to impinge directly in the rolling contact region. A sufficient quantity of oil was supplied in each instance to assure adequate lubrication and to control the bearing operating temperature at the level given under the test conditions.

B. Endurance Test Procedure and Test Conditons

Prior to use, the residual anti-rust preservative was removed from each test bearing specimen by washing with a solvent. To facilitate mounting of the test bearing on the machine arbor, the bearing was heated in an oven to 408 K (135°C) to expand the inner ring sufficiently to clear the bearing seat. When cool, the interference fit was 0.025 to 0.035 mm. The clearance between the outer ring and test machine housing ranged from 0.025 to 0.045 mm. The housing was installed and the rest of the machine hardware assembled.

The test conditions, i.e. lubricants, applied loads, and inner ring speeds, for each of the five test bearing groups are listed in Table 8.

TABLE 8

OPERATIONAL TEST CONDITIONS

Test Bearing Group	Lot No.	Lubricant Gov't. Spec. No.	Applied Thrust Force kN	Speed rad/s (rpm)	Avg. Operating Temp. K	Theoretical Life L_{10} revs x 10^6	Hertz Stress GPa
A	1	MIL-L-23699	9.52	576 (5500)	343	209	1.90
B	1	MIL-L-23699	15.7	576 (5500)	343	46.5	2.24
C	2	MIL-L-23699	33.4	1016 (9700)	368	10	2.48
D	2	MIL-L-7808H	33.4	1016 (9700)	368	10	2.48
E	1	MIL-L-23699	26.2	36.7 (350)	303	10	2.48

AL79T027

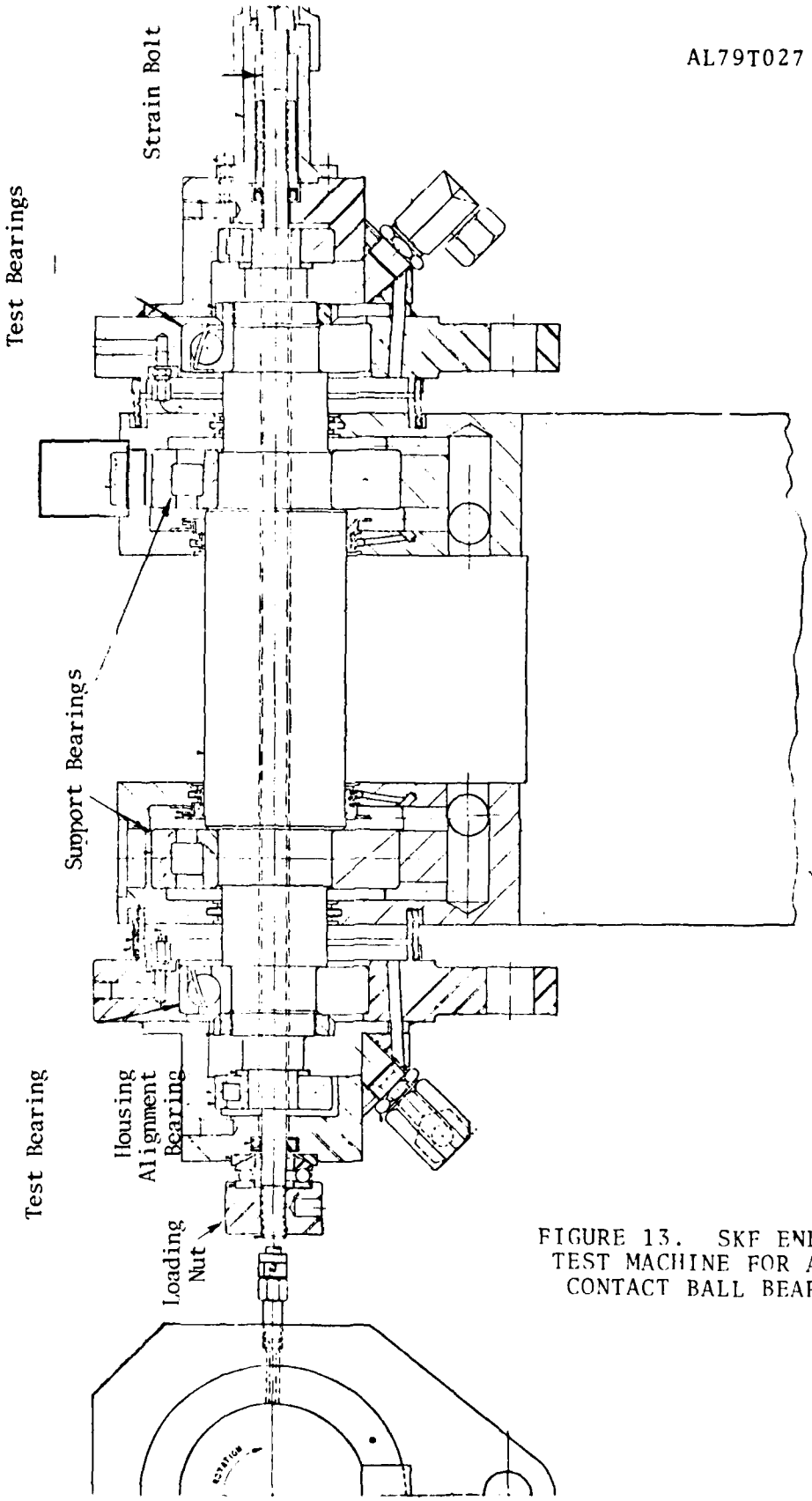
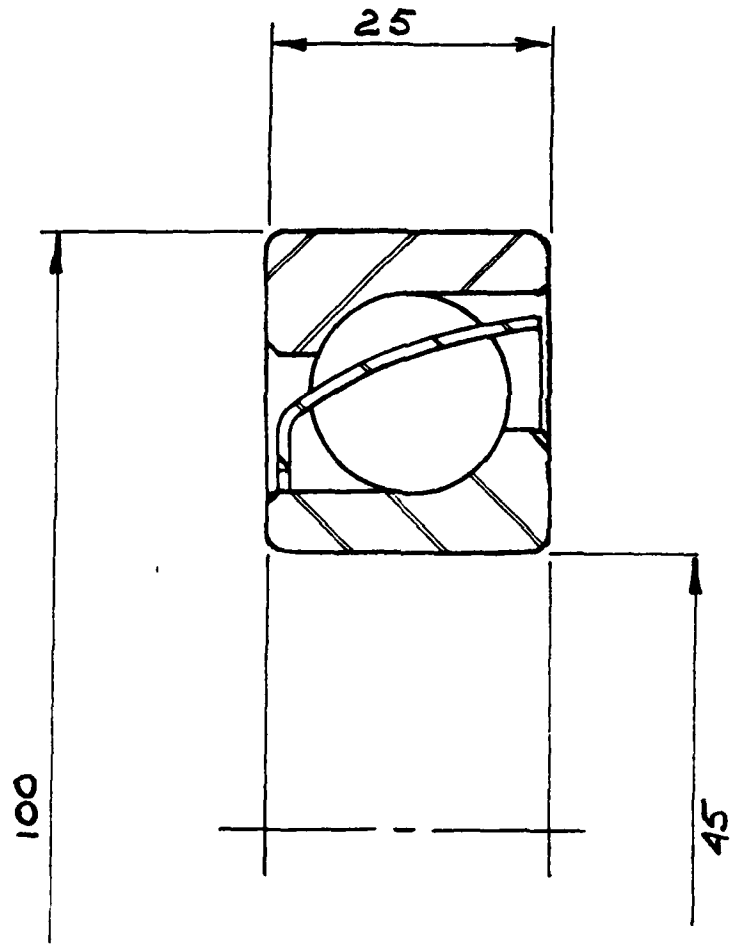


FIGURE 13. SKF ENDURANCE TEST MACHINE FOR ANGULAR CONTACT BALL BEARINGS

C. Bearing Manufacture Procedure

A 50 bearing test lot of 45 mm bore angular contact ball bearings was fabricated from aircraft certified Vacuum Induction Melt, Vacuum Arc Remelt (VIMVAR) M50 tool steel of the basic design shown in Figure 14. The finished components were dimensionally audited on a sample basis to document the conformity of the test bearings to the design configuration. The race surfaces of the rings were also subjected to a 100% visual inspection. During the visual examination, it was noted that some of the races contained finishing discontinuities in the area of the ball track. While these features are commonly found in bearings used in the field, and particularly in tool steel bearings, it was felt that interactions could occur under the abnormally high load levels used in endurance testing which would bias the program results. It was decided to refinish the rings to eliminate these discontinuities.

A number of acceptable outer rings were identified so the bearings were refinished into two specific lots. Lot 1 contains thirty bearings having original outers and refinished inners which provides a contact angle of 28°. The second lot (Lot 2) was made up of twenty bearings having both rings refinished and giving a 43° contact angle. Table 9 gives the basic internal geometry differences resulting from the modifications described. The loading conditions were then recalculated for the modified designs to provide the desired test stress levels.



7309 VED

FIGURE 14 ANGULAR CONTACT BALL BEARING

TABLE 9

BASIC INTERNAL GEOMETRY DIFFERENCES
7309 VED VIMVAR M-50 TEST BEARINGS

	LOT 1	LOT 2
Contact Angle°	28	43
Raceway Ball Groove Radius		
Inner mm	9.107	9.107
Outer mm	9.037	9.071
Balls	12-11/16" Diameter	

D. Endurance Test Results and Discussion

The endurance data collected on the five groups of bearings tested under the various test conditions outlined previously are presented in the following paragraphs and Tables 10 through 14. Each table lists the life of each individual bearing specimen in millions of revolutions and the mode of failure.

In those instances where a sufficient number of failures had occurred, the life data of each bearing group have been statistically treated according to an SKF developed maximum likelihood computer program MAXLIKE [5 and 6]. The program establishes the L_{10} and L_{50} lives and 90% confidence interval estimates for each bearing specimen group, as well as the slope of the experimental Weibull distribution.

A summary of the test results is presented in Table 15.

1. Test Group A

Test Group A (Lot No. 1) was run at 576 rad/s (5500 rpm) under an applied thrust force of 9.52 kN, and lubricated with Mobil Jet II Synthetic lubricant (MIL-L-23699). As shown in Table 10, testing of the bearings had been suspended at a life in excess of 500×10^6 revs. which is twice the theoretical L_{10} life of 209×10^6 revs. For use in the data base and subsequent analyses, the experimental L_{10} life of this group has been estimated as being greater than 400×10^6 revs.

[5] McCool, J. I., "Evaluating Weibull Endurance Data by the Method of Maximum Likelihood", ASLE Trans., No. 13, 189-202 (1970).

[6] McCool, J. I., "Inference on Weibull Percentiles and Shape Parameter from Maximum Likelihood Estimates", IEEE Trans. on Reliability, No. R-19, 177-59 (1970).

2. Test Group B

Test Group B (Lot No. 1) was run at 576 rad/s (5500 rpm), under an applied thrust force of 15.7 kN and lubricated with Mobil Jet II Synthetic lubricant (MIL-L-23699). The test results given in Table 11 show that two failures were experienced at lives of 430 and 713 x 10^6 revs while the majority of the bearings were suspended at a life of 800+ x 10^6 revs. Analysis of these data indicate the experimental L_{10} life is 549 x 10^6 revs. which is 12 times greater than the theoretical L_{10} life of 46.5 x 10^6 revs. An example of a typical inner ring failure is shown in Figure 15.

3. Test Group C

Test Group C (Lot 2) was run at 1016 rad/s (9700 rpm) under an applied thrust force of 33.4 kN and lubricated with Mobil Jet II Synthetic lubricant (MIL-L-23699). Details of the test results are presented in Table 12 which shows that five failures were experienced at lives ranging from 14 to 261 x 10^6 revs. The experimental L_{10} life of 40 x 10^6 revs. is 4 times greater than the theoretical L_{10} value of 10 x 10^6 revs. Examples of typical inner ring failures are shown in Figure 15.

4. Test Group D

Test Group D was run under the same test conditions as Group C except for the lubricant. These bearings were lubricated with Exxon Turbo Lubricant 2389 (MIL-L-7808H Qual IMI). Details of the test results are given in Table 13 which shows that four failures were experienced at lives ranging from 61 to 285 x 10^6 revs. The experimental L_{10} life of 43.8 x 10^6 revs. is again approximately 4 times the theoretical L_{10} value of 10 x 10^6 revs. Examples of typical inner ring failures are shown in Figure 16.

5. Test Group E

Test Group E (Lot 1) was run at 36.7 rad/s (350 rpm), under an applied thrust force of 26.2 kN and lubricated with Mobil Jet II Synthetic lubricant (MIL-L-23699). The bearings were suspended at a life of 90 x 10^6 revs. as shown in Table 14. Again, for inclusion in the data base, the experimental L_{10} life was estimated to be greater than 90 x 10^6 revs. which is 9 times greater than the theoretical L_{10} value of 10 x 10^6 revs.

TABLE 10

ENDURANCE TEST DATA FROM GROUP A

TEST BEARING: 7309 VED VIMVAR M-50 Steel; Lot 1

SPEED: 576 rad/s (5500 rpm) APPLIED LOAD: 9.52 kN (2140 lbf)

LUBRICATION: Circulating Mobil Jet II (MIL-L-23699)

Bearing No.	Life (Million Revs.)	Mode of Failure
111	545	Suspended
112	545	Suspended
113	548	Suspended
114	548	Suspended
115	538	Suspended
116	538	Suspended
117	509	Suspended
118	509	Suspended
119	381	Suspended
120	381	Suspended

Theoretical $L_{10} = 209 \times 10^6$ revs.

Experimental $L_{10} > 400 \times 10^6$ revs.

TABLE 11

ENDURANCE TEST DATA FROM GROUP B

TEST BEARINGS: 7309 VED VIMVAR M-50 Steel; Lot 1

SPEED: 526 rad/s (5500 rpm) APPLIED LOAD: 15.7 kN (3530 lbf)

LUBRICATION: Circulating Mobil Jet II (MIL-L-23699)

Bearing No.	Life (Million Revs.)	Mode of Failure
122	713	Inner Ring Spall
123	713	Suspended
124	834	Suspended
125	834	Suspended
126	806	Suspended
127	806	Suspended
128	430	Inner Ring Spall
129	430	Suspended
130	827	Suspended
131	827	Suspended

Theoretical $L_{10} = 46.5 \times 10^6$ revs.

Experimental values in million revolutions

$L_{10} = 549$ $L_{50} = 2548$

L_{10} LCL = 16.6 L_{50} LCL = 885

L_{10} UCL = 1130 L_{50} UCL = 759×10^6

Weibull Slope = 2.9

TABLE 12
ENDURANCE TEST DATA FROM GROUP C

TEST BEARINGS: 7309 VED VIMVAR M-50 Steel; Lot 2

SPEED 1016 rad/s (9700 rpm) APPLIED LOAD: 33.4 kN (7500 lbf)

LUBRICATION: Circulating Mobil Jet II (MIL-L-23699)

Bearing No.	Life (Million Revs.)	Mode of Failure
201	257	Suspended
202	257	Inner Ring Spall
203	261	Inner Ring Spall
204	331	Suspended
205	70	Inner Ring Spall
206	73	Suspended
207	14	Inner Ring Spall
208	207	Inner Ring Spall
209	406	Suspended
210	259	Suspended

Theoretical $L_{10} = 10 \times 10^6$ revs.

Experimental values in million revolutions

$L_{10} = 40$ $L_{50} = 352$

L_{10} LCL = 1.4 L_{50} LCL = 149

L_{10} UCL = 108 L_{50} UCL = 1580

Weibull Slope = 1.1

TABLE 13

ENDURANCE TEST DATA FROM GROUP D

TEST BEARINGS: 7309 VED VIMVAR M-50 Steel; Lot 2

SPEED:1016 rad/s (9700 rpm) APPLIED LOAD:33.4 kN (7500 lbf)

LUBRICATION: Circulating Exxon Turbo Oil 2389 (MIL-L-7808H Qual IMI)

Bearing No.	Life (Million Revs.)	Mode of Failure
211	285	Inner Ring Spall
212	315	Suspended
213	315	Suspended
214	315	Suspended
215	373	Suspended
216	82	Inner Ring Spall
217	61	Inner Ring Spall
218	63	Inner Ring Spall
219	226	Suspended
220	291	Suspended

Theoretical $L_{10} = 10 \times 10^6$ revs.

Experimental values in million revolutions

$L_{10} = 43.8$ $L_{50} = 625$

L_{10} LCL = 0.37 L_{50} LCL = 195

L_{10} UCL = 140 L_{50} UCL = 9623

Weibull Slope = 0.99

TABLE 14

ENDURANCE TEST DATA FROM GROUP E

TEST BEARINGS: 7309 VED VIMVAR M-50 Steel; Lot 1

SPEED: 36.7 rad/s (350 rpm) APPLIED LOAD: 26.2 kN (5900 lbf)

LUBRICATION: Circulating Mobil Jet II (MIL-L-23699)

Bearing No.	Life (Million Revs.)	Mode of Failure
101	90	Suspended
102	90	Suspended
103	90	Suspended
104	90	Suspended
105	90	Suspended
106	90	Suspended
107	90	Suspended
108	90	Suspended
109	90	Suspended
110	90	Suspended

Theoretical $L_{10} = 10 \times 10^6$ revs.

Experimental $L_{10} = > 90 \times 10^6$ revs.

TABLE 15

SUMMARY OF ENDURANCE LIFE RESULTS
7309 VED ANGULAR CONTACT BALL BEARINGS
Material: VIMVAR M-50 Steel

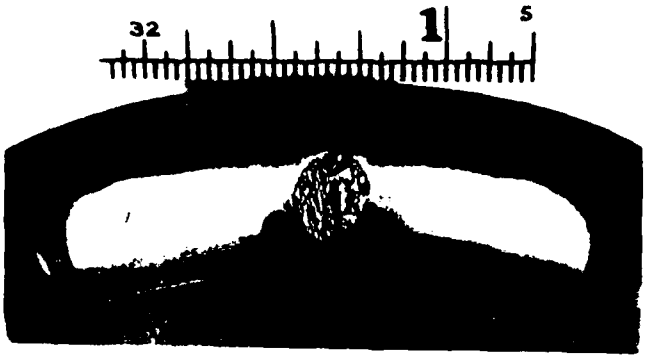
Test Bearing Group	Lubricant Gov't MIL-L Spec. No.	Test Conditions: Thrust Force kN	Test Conditions: Speed rad/s (rpm)	Hertz Stress GPa	No. of Failures	L_{10} LIFE-MILLION REVS. Theo (a)	Experimental: Median	Experimental: LCL (b)	Experimental: UCL (c)	Weibull Slope Beta	H/SIG Value	FILFAC a_3	MATFAC a_2
A	23699	9.52	576 (5500)	1.90	0	209	>400	-	-	-	3.2	2.33	>0.82
B	23699	15.71	576 (5500)	2.24	1	46.5	549	0.17	1130	2.9	3.08	2.32	5.56
C	23699	33.4	1016 (9700)	2.48	5	10	40	1.4	108	1.1	3.64	2.39	2.22
D	7808H	33.4	1016 (9700)	2.48	4	10	43.8	0.37	140	0.99	2.34	2.24	2.70
E	23699	26.2	36.7 (350)	2.48	0	10	>90	-	-	-	0.98	0.49	>18.6

Test Group = 10 bearings

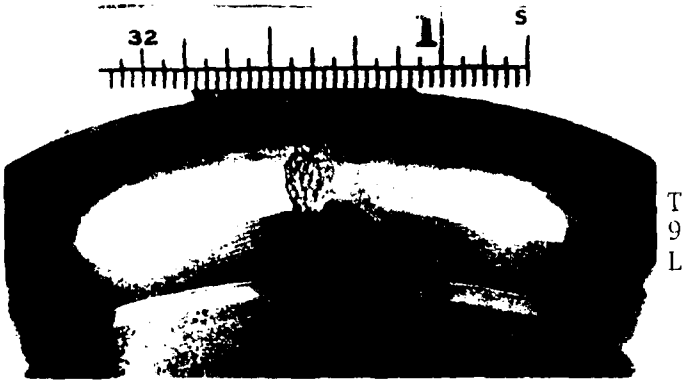
(a) Theoretical calculated life from TABACY; life modification factors not included

(b) LCL - Lower Confidence Limit

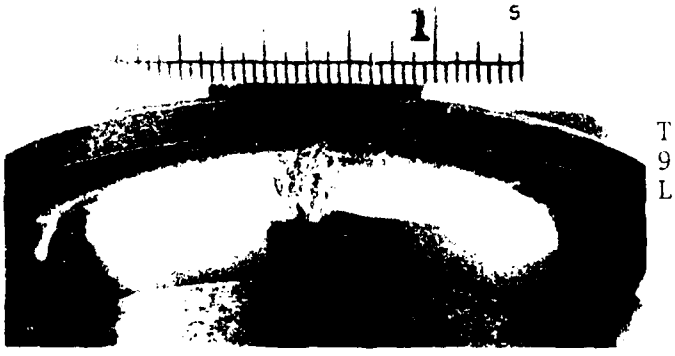
(c) UCL - Upper Confidence Limit



Test Group B Brg. No. 128
5500 RPM Fa = 15.7 kN
Life = 430 x 10^6 revs.



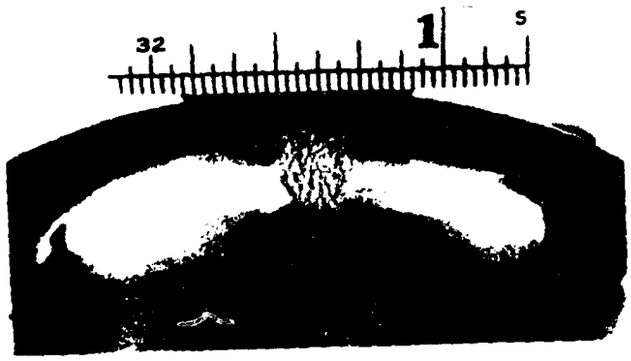
Test Group C Brg. No. 203
9700 RPM Fa = 33.4 kN
Life = 261 x 10^6 revs.



Test Group C Brg. No. 207
9700 RPM Fa = 33.4 kN
Life = 14 x 10^6 revs.

FIGURE 15. TYPICAL EXAMPLES OF INNER RING BEARING FAILURES
7309 VFD VIMVAR M-50 STEEL WITH
MIL-L-23699 OIL

Test Group D Brg. No. 211
9700 RPM Fa = 33.4 kN
Life = 285×10^6 revs.



Test Group D Brg. No. 217
9700 RPM Fa = 33.4 kN
Life = 61×10^6 revs.

FIGURE 16. TYPICAL EXAMPLES OF INNER RING BEARING FAILURES
-309 VED VIMVAR M-50 STEEL
WITH MIL-L-7808H OIL

E. Principle Experimental Results

1. The endurance testing of these angular contact ball bearings manufactured from VIMVAR M50 tool steel produced experimental lives ranging from 4 to 12 times the respective theoretical values. Applying the calculated values of the a_3 application factor, the apparent values of the a_2 material factor ranged from 2.2 to 18.6.

2. Test groups C and D were run with MIL-L-23699 and MIL-L-7808 lubricant respectively while all other test conditions remained constant. The apparent values of the a_2 factors that were achieved in these tests were 2.2 and 2.7 considering lubricant factors dependent upon specific lubricant viscosity at the test conditions. The difference in these values is not statistically significant indicating that the variation in lubricant chemistry had no apparent influence on bearing life.

3. Test groups C and E were run at differing speeds, 1016 rad/s and 36.7 rad/s, with all other conditions held constant. These tests yielded apparent a_2 material factors of 2.2 and 18.6 respectively. This result seems to imply the presence of a significant effect of speed on bearing life, but in the opposite direction from that normally theorized effect of increasing stressing rate producing a life enhancement effect. The significance of this effect is questionable due to the small amount of data available.

4. While the test loads were systematically varied in three groups, A, B and the 7309 test of Phase I, the data are not sufficient to allow the verification of the load life relationship. The insufficiency of data exists since no failures were achieved in test Group A and the Phase I results were biased due to premature ball failures and/or other extraneous causes.

IV. CONCLUSIONS

1. The best current estimate of the value of the a_2 life modification factor for material is between 3.55 and 5.65 for VIMVAR M50 tool steel. It is recommended that $a_2 = 5$ be used for the calculation of the adjusted rating life for Army Helicopter systems employing bearings manufactured from this material.

2. For bearing applications where the effects of load distribution variations and/or temperature extremes are within the normally applied limits of system design, the a_3 life adjustment factor for application conditions can be approximated as a lubrication factor. It is recommended that values be assigned to this factor on the basis of the magnitude of the film parameter using the relationship established in 1971 by ASME [3].

3. Both the experimental and statistical analyses indicate that the effects of lubricant type (chemistry), operating speed and lubricant viscosity on bearing life are adequately treated in the existing life calculation methods. Therefore, a single value of a_2 can be utilized across the range of variations of these parameters expected to exist in helicopter engines and gearboxes.

4. Continued evidence was noted of systematic errors in the life calculation methods as applied to element test configurations. The presence of these errors limit the effectiveness of element testing as a means of establishing reliable material life relationships.

V. RECOMMENDATIONS

Two of the test lots included in this effort, Groups A and E, were still running without failures at the conclusion of the program. The absence of statistically significant life data in these instances creates gaps in the data matrix and prevents the total analysis of the influences of variations in environmental effects on bearing life. Since the major cost elements have already been expended in these efforts, it would be extremely cost effective and beneficial to continue the testing of these lots.

The results of the Phase I tests on cylindrical roller bearings indicated that the life modifying factor for line contact bearings is underestimated. In Phase II, an attempt was made to analyze the existing data base to establish the validity of this observed trend. However, the amount of data available were insufficient to allow the satisfactory completion of this study. The existance of this possible inconsistancy, coupled with the large volume of cylindrical roller bearings used in aerospace applications, creates a significant area of question for the Army in the evaluation of proposed aircraft system designs.

The elimination of this problem area requires the accumulation and systematic evaluation of additional life test data collected on cylindrical roller bearings under a variety of operating conditions containing controlled variations. The data would then be analyzed to create a better estimate of the actual life which can be expected from cylindrical roller bearings under these ranges of operating parameters. The theoretical life calculation techniques could be examined with this in mind to determine which of the analytical models, e.g. load distribution effects, lubricant film effects, etc. need modification in order to correct the existing situation. While the development of a new life model is an extensive task, the conduct of a life test series with cylindrical roller bearings patterned after the ball bearing series reported herein would (a) provide an improved value of an apparent a_2 factor for cylindrical roller bearings which could be used by the Army in evaluating line contact systems, and (b) provide the necessary starting point for the eventual modification of the line contact life model.

One major shortcoming which continues to be apparent from analysis of the data base is the current inadequacy of life estimates obtained from element test series. While major analytical work is required to correct the predictive deficiencies, the data could be treated to yield correlation factors which

could be applied to specific types of element test generated data to provide more adequate extrapolations for bearing applications. Judging from the amount of element test data included in the data base, this would be an extremely important value to have available for future use.

LIST OF REFERENCES

[1] Lundberg, G. and Palmgren A., "Dynamic Capacity of Rolling Bearings", Acta Polytechnica, Mechanical Engineering Series 1, Proceedings of the Royal Swedish Academy of Engineering, Vol. 7, No. 3, 1947.

[2] Lundberg, G. and Palmgren A., "Dynamic Capacity of Roller Bearings", Proceedings of the Royal Swedish Academy of Engineering, Vol. 2, No. 4, 1952.

[3] Bamberger, E. N., Harris, T. A., Kacmarsky, W. M. Moyer, C. A., Parker, R. J., Sherlock, J. J., and Zaretsky, E. V., Life Adjustment Factors for Ball and Roller Bearings, The American Society of Mechanical Engineers, 1971.

[4] The Health Sciences Computing Facility sponsored by NIH Special Research Resources Grant RR-3.

[5] McCool, J. I., "Evaluating Weibull Endurance Data by the Method of Maximum Likelihood", ASLE Trans., No. 13, 189-202 (1970).

[6] McCool, J. I., "Inference on Weibull Percentiles and Shape Parameter from Maximum Likelihood Estimates", IEEE Trans. on Reliability, No. R-19, 177-59 (1970).

APPENDIX A

DATA BASE FOR ELEMENTS

CASE LABEL NO.	1 REF 10 N 19 FILFAC	2 TYPE 11 R 20 MATFAC	3 MAT 12 L10EX 21 WTFAC	4 PROC 13 BETA 22 LOGMAT	5 STRESS 14 SPEED	6 SIZE 15 TEMP	7 H 16 LUBE	8 SIGMA 17 VIS	9 L10TH 18 H/SIG
1	1002.0000	1.000	2.0000	1.000	800.0000	.3750	.7000	12.1000	.2146
	4.0000	4.0000	5.2500	4.2800	12500.0000	215.0000	1.000	4.8000	.0579
	.2000	122.3443	19.2274	4.8069					
2	1004.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.9300	4.2000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.6576	18.9577	1.8958					
3	1005.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.2900	5.1100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	9.2348	22.2293	2.2230					
4	1006.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	2.8400	5.6300	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	20.5309	15.0607	3.0121					
5	1007.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	6.0000	6.0000	2.8700	5.6800	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	20.5456	18.1359	3.0226					
6	1008.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	10.000	10.000	3.8100	7.0500	12500.0000	300.0000	1.000	2.4000	.0579
	.2000	27.2749	33.0597	3.3060					
7	1009.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	10.000	10.000	2.7400	3.8300	12500.0000	300.0000	1.000	2.4000	.0579
	.2000	19.6150	29.7629	2.9763					
8	1010.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.8500	5.8400	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.0849	18.0582	1.8058					
9	1011.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.9200	5.4000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.5861	18.8995	1.8850					
10	1012.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.8300	5.4000	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	13.1005	25.7265	2.5727					
11	1013.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.2800	5.9800	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	9.1632	22.1520	2.2152					
12	1014.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.3000	5.2500	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	9.1064	22.3070	2.2307					
13	1015.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.0700	2.1400	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	7.6599	20.3600	2.0360					
14	1016.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	8.0000	8.0000	1.3100	5.7100	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	9.3760	17.9069	2.2384					
15	1017.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.9100	4.7300	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	13.6732	26.1544	2.6154					
16	1018.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.5400	5.5400	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	11.0245	24.0012	2.4001					
17	1019.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	3.0000	3.0000	2.6400	3.9200	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	18.8991	8.8173	2.9391					
18	1020.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.4400	1.3500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	5.1499	3.4421	1.1474					
19	1021.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.7900	9.6200	12500.0000	600.0000	1.000	.7200	.0248
	.2000	5.6554	17.3264	1.7326					

20	1022.0000	1.000	2.0000	1.000	680.0000	.3750	.3000	12.1000	.9130
	10.000	10.000	.7000	9.3600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	3.8335	13.4378	1.3438					
21	1023.0000	1.000	2.0000	1.000	680.0000	.3750	.3000	12.1000	.9130
	10.000	10.000	.5100	5.7200	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.7930	10.2711	1.0271					
22	1024.0000	1.000	2.0000	1.000	700.0000	.3750	2.5000	12.1000	.6984
	5.0000	5.0000	5.5100	3.5200	12500.0000	250.0000	1.000	3.5000	.2066
	.2000	39.4445	18.3745	3.6749					
23	1025.0000	1.000	2.0000	1.000	700.0000	.3750	2.5000	12.1000	.6984
	5.0000	5.0000	6.1600	5.7100	12500.0000	250.0000	1.000	3.5000	.2066
	.2000	44.0980	18.9321	3.7864					
24	1026.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.8300	3.2900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	20.2593	30.0861	3.0086					
25	1027.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.5200	4.7600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	18.0401	28.9259	2.8926					
26	1028.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.4100	3.9900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	10.0939	23.1193	2.3119					
27	1029.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.4900	1.5900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	3.5078	12.5499	1.2550					
28	1030.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	9.0000	.8900	1.3900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.3713	16.6662	1.8518					
29	1031.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	11.0000	10.000	2.5800	4.4500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	18.4696	29.1613	2.9161					
30	1032.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	6.0000	6.0000	1.6400	1.6900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	11.7404	14.7782	2.4630					
31	1033.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.6700	8.8400	12500.0000	600.0000	1.000	.7200	.0248
	.2000	19.1139	29.5041	2.9504					
32	1034.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.2800	8.1600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	16.3220	27.9251	2.7925					
33	1035.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.7000	6.3900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	19.3287	29.6159	2.9616					
34	1036.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	5.0600	2.8200	12500.0000	325.0000	1.000	2.0800	.0579
	.2000	36.2233	17.9485	3.5897					
35	1037.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	18.2700	4.8900	12500.0000	325.0000	1.000	2.0800	.0579
	.2000	130.7905	24.3680	4.8736					
36	1038.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.1400	7.0000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	15.3198	27.2914	2.7291					
37	1039.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.9100	6.4400	12500.0000	600.0000	1.000	.7200	.0248
	.2000	13.6732	26.1544	2.6154					
38	1040.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.5200	5.0100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	18.0401	28.9259	2.8926					
39	1041.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	6.6800	6.7600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	47.8205	19.3373	3.8675					
40	1042.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	3.0900	4.6600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	22.1206	30.9651	3.0965					
41	1043.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.4700	7.2600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	10.5234	23.5360	2.3536					

42	1044.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	9.0000	1.2700	5.6100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	9.0916	19.8662	2.2074					
43	1045.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	8.0000	8.0000	5.5700	3.7000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	58.5094	33.8158	4.2270					
44	1046.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.2100	4.1300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	8.6621	21.5895	2.1590					
45	1047.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.0300	7.4600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.3735	19.9789	1.9979					
46	1048.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	1.8900	3.0700	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	13.5301	13.0246	2.6049					
47	1049.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	2.2800	5.9800	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	16.3220	13.9626	2.7925					
48	1050.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	1.8200	6.1400	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	13.0289	12.8359	2.5672					
49	1051.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	1.5000	3.7700	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	10.7381	11.8690	2.3738					
50	1052.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.5900	4.6000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.2237	7.2035	1.4407					
51	1053.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	4.0000	4.0000	.9600	2.9100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.4724	7.7101	1.9275					
52	1054.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.5900	4.6000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.2237	7.2035	1.4407					
53	1055.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.2400	1.1900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	1.7181	2.7061	.5412					
54	1056.0000	1.000	2.0000	1.000	700.0000	.3750	.4000	12.1000	.6984
	5.0000	5.0000	.8500	4.8400	12500.0000	500.0000	1.000	.9600	.0331
	.2000	6.0849	9.0291	1.8058					
55	1057.0000	1.000	2.0000	1.000	700.0000	.3750	.4000	12.1000	.6984
	5.0000	5.0000	1.1900	3.6200	12500.0000	500.0000	1.000	.9600	.0331
	.2000	8.5189	10.7115	2.1423					
56	1058.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	1.0200	5.7100	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	7.3019	9.9407	1.9881					
57	1059.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	5.0000	5.0000	2.5800	8.5600	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	18.4696	14.5806	2.9161					
58	1060.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	1.6500	12.5900	12500.0000	325.0000	1.000	2.0800	.0579
	.2000	11.8120	12.3456	2.4691					
59	1061.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	2.1000	3.3800	12500.0000	325.0000	1.000	2.0800	.0579
	.2000	15.0359	13.5514	2.7103					
60	1062.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	9.0000	6.0300	2.3500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	43.1673	33.8859	3.7651					
61	1063.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.7200	3.5900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	12.3131	25.1066	2.5107					
62	1064.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	4.0000	4.0000	2.5200	9.3600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	18.0401	11.5704	2.8926					
63	1065.0000	1.000	2.0000	1.000	700.0000	.3750	.4000	12.1000	.6984
	4.0000	4.0000	4.0200	9.9400	12500.0000	500.0000	1.000	.9600	.0331
	.2000	28.7792	13.4385	3.3596					

64	1066.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	4.0000	4.0000	11.4300	4.8500	12500.0000	325.0000	1.000	2.0800	.0579
	.2000	60.3484	16.4005	4.1001					
65	1067.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	11.8900	3.8100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	14.8511	10.7923	2.6981					
66	1068.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	2.2000	5.3500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	15.7493	13.7840	2.7568					
67	1069.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	11.1200	4.5500	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	13.8893	13.1556	2.6311					
68	1070.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.9300	7.9700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	13.8164	26.2586	2.6259					
69	1071.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.1100	5.9500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.9462	20.7270	2.0727					
70	1072.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.0400	4.3000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.4451	20.0756	2.0076					
71	1073.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.5300	9.3300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	10.9529	23.9360	2.3936					
72	1074.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.7600	4.0900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	12.5994	25.3365	2.5336					
73	1075.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.3400	3.5700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	9.5927	22.6101	2.2610					
74	1076.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.0400	4.6500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.4451	20.0756	2.0076					
75	1077.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.0600	6.7400	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.5883	20.2660	2.0266					
76	1078.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.8300	5.3100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	5.9418	17.8201	1.7820					
77	1079.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.9100	7.4600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.5145	18.7402	1.8740					
78	1080.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.6300	3.5700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.5100	15.0630	1.5063					
79	1081.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	9.0000	.7400	5.3300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	5.2975	15.0051	1.6672					
80	1082.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.8700	4.6100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.2281	18.2907	1.8291					
81	1083.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.1100	7.2600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.9462	20.7270	2.0727					
82	1084.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.6400	7.3500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.5816	15.2205	1.5220					
83	1085.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.5000	6.7900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	3.5794	12.7519	1.2752					
84	1086.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.2900	2.5100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	9.2348	22.2298	2.2230					
85	1087.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	2.7200	7.2500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	19.4718	29.6897	2.9690					

86	1088.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.7300	4.5700	12500.0000	600.0000	1.000	.7200	.0243
	.2000	12.3647	25.1646	2.5165					
87	1089.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.6300	3.0700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	11.6688	24.5492	2.4569					
88	1090.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	9.0000	2.0000	10.7800	12500.0000	600.0000	1.000	.7200	.0248
	.2000	14.3175	23.9533	2.6615					
89	1091.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	5.0000	1.9100	6.7000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	13.6732	23.5390	2.6154					
90	1092.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	4.8400	4.6200	12500.0000	215.0000	1.000	4.8000	.0579
	.2000	34.6484	17.7263	3.5453					
91	1093.0000	1.000	2.0000	1.000	800.0000	.3750	.7000	12.1000	.2100
	5.0000	5.0000	2.2200	2.3800	12500.0000	215.0000	1.000	4.8000	.0579
	.2000	52.8596	19.8382	3.9676					
92	1094.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	1.3700	1.4700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	1.7112	2.6859	.5372					
93	1095.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	6.1100	5.3300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.6316	10.1615	2.0323					
94	1096.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	15.4200	12.4300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	19.2602	14.7902	2.9580					
95	1097.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	15.6300	3.0100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	19.5225	14.8578	2.9716					
96	1098.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	19.7700	2.8500	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	24.6935	16.0327	3.2065					
97	1099.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	7.8200	9.8200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	9.7675	11.3953	2.2791					
98	1100.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	3.1200	5.5900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.8970	6.8010	1.3602					
99	1101.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	7.9300	8.5300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	9.9046	11.4651	2.2930					
100	1102.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	4.5700	7.6500	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.7081	8.7094	1.7419					
101	1103.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	5.0200	6.0300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.2702	9.1740	1.8353					
102	1104.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	3.0500	3.1900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.8096	6.6876	1.3375					
103	1105.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	3.0000	3.7300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	21.4763	30.6695	3.0569					
104	1106.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	8.0000	8.0000	2.9400	2.6600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	21.0467	24.3740	3.0467					
105	1107.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.9000	6.0000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.4429	9.3149	1.8630					
106	1108.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	4.0000	6.5700	4.0000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	47.0331	15.4034	3.8509					
107	1109.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	1.1100	8.1600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.9462	10.3635	2.0727					

108	1110.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	7.0000	7.0000	2.4000	3.0400	12500.0000	600.0000	1.000	.7200	.0248
	.2000	17.1810	19.9066	2.8438					
109	1111.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	.5400	1.3600	12500.0000	215.0000	1.000	4.8000	.0579
	.2000	3.8657	6.7608	1.3522					
110	1112.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	.8200	3.3200	12500.0000	215.0000	1.000	4.8000	.0579
	.2000	5.8702	8.8494	1.7699					
111	1113.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.3000	2.7300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.1476	3.8218	.7644					
112	1114.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.2200	2.7300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	1.5749	2.2710	.4542					
113	1115.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.7300	4.5700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	5.2259	16.5363	1.6536					
114	1116.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.9400	4.6600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	13.8880	26.3102	2.6310					
115	1117.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.5600	3.5900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.0089	13.8852	1.3885					
116	1118.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.4700	4.6800	12500.0000	600.0000	1.000	.7200	.0248
	.2000	10.5234	23.5360	2.3536					
117	1119.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.9000	3.8100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	13.6016	26.1019	2.6102					
118	1120.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.1100	3.0900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.9462	20.7270	2.0727					
119	1121.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	6.0000	6.0000	3.3000	3.4200	12500.0000	300.0000	1.000	2.4000	.0579
	.2000	23.4239	18.9735	3.1623					
120	1122.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	6.0000	6.0000	4.6200	3.7100	12500.0000	300.0000	1.000	2.4000	.0579
	.2000	33.0735	20.9324	3.4987					
121	1123.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.5400	2.5700	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	11.0245	24.0012	2.4001					
122	1124.0000	1.000	2.0000	1.000	700.0000	.3750	.6000	12.1000	.6984
	10.000	10.000	1.0000	2.1000	12500.0000	400.0000	1.000	1.4000	.0496
	.2000	7.1588	19.6834	1.9683					
123	1125.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.4100	7.4900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	10.3939	23.1193	2.3119					
124	1126.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.7000	3.6700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	5.0111	16.1166	1.6117					
125	1127.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.0100	5.8100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.2303	19.7829	1.9783					
126	1128.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.9000	3.7500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.4429	18.6298	1.8630					
127	1129.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	3.4500	5.7400	12500.0000	600.0000	1.000	.7200	.0248
	.2000	24.6977	32.0671	3.2067					
128	1130.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	3.3800	7.0500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	24.1966	31.8621	3.1862					
129	1131.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	1.7900	5.0000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	12.8142	25.5055	2.5506					

130	1132.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.698
	10.000	10.000	1.0300	2.6300	12500.0000	600.0000	1.000	.7200	.024
	.2000	7.3735	19.9789	1.9979					
131	1133.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	8.0000	8.0000	1.8200	5.5000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	13.0289	20.5374	2.5672					
132	1134.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	10.9100	4.7700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	78.1021	21.7901	4.3580					
133	1135.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	9.0000	1.4200	2.4300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	10.1654	20.8709	2.3190					
134	1136.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.5800	3.8700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.1521	14.2361	1.4236					
135	1137.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	9.0000	.6400	3.6700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.5816	13.6984	1.5220					
136	1138.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	9.0000	9.0000	1.0500	7.7800	12500.0000	600.0000	1.000	.7200	.0248
	.2000	7.5167	18.1541	2.0171					
137	1139.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.9300	6.9500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	6.6576	18.9577	1.8958					
138	1140.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	4.7000	4.4000	12500.0000	600.0000	1.000	.7200	.0248
	.2000	33.6462	17.5795	3.5159					
139	1144.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	4.0000	6.8000	15.7300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	48.6796	15.5410	3.6853					
140	1145.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.6600	3.6200	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.7348	15.5282	1.5528					
141	1146.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	3.9600	4.3700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	28.3987	33.4459	3.3445					
142	1147.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	4.7100	6.2100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	33.7178	17.5931	3.5189					
143	1148.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	3.3300	3.4300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	23.8387	15.8965	3.1713					
144	1149.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	10.000	10.000	.6900	7.8900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	4.9395	15.9727	1.5973					
145	1151.0000	1.000	2.0000	1.000	700.0000	.3750	3.4000	12.1000	.6984
	5.0000	5.0000	1.2700	11.9200	12500.0000	350.0000	1.000	1.8300	.2810
	.2000	7.6599	10.1800	2.0360					
146	1152.0000	1.000	2.0000	1.000	700.0000	.3750	3.4000	12.1000	.6984
	5.0000	5.0000	.8800	7.5200	12500.0000	350.0000	1.000	1.8300	.2810
	.2000	6.2997	9.2025	1.8405					
147	1153.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	1.3300	9.0400	12500.0000	350.0000	1.000	1.8300	.0579
	.2000	9.5212	11.2676	2.2535					
148	1154.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	1.1000	7.0800	12500.0000	350.0000	1.000	1.8300	.0579
	.2000	7.8746	10.3182	2.0636					
149	1155.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.4900	12.8900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	3.5078	6.2749	1.2550					
150	1156.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.3800	15.0700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.7201	5.0038	1.0008					
151	1157.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.4100	7.9300	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.9351	5.8737	1.0767					

152	1158.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.2100	3.7500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	1.5033	2.0384	.4077					
153	1159.0000	1.000	2.0000	1.000	700.0000	.3750	3.4000	12.1000	.6984
	5.0000	5.0000	1.0700	11.9200	12500.0000	350.0000	1.000	1.8300	.2810
	.2000	7.6599	10.1800	2.0360					
154	1160.0000	1.000	2.0000	1.000	700.0000	.3750	3.4000	12.1000	.6984
	5.0000	5.0000	.8800	7.5200	12500.0000	350.0000	1.000	1.8300	.2810
	.2000	6.2997	9.2025	1.8405					
155	1161.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	1.3300	9.0400	12500.0000	350.0000	1.000	1.8300	.0579
	.2000	9.5212	11.2676	2.2535					
156	1162.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	1.1000	7.0800	12500.0000	350.0000	1.000	1.8300	.0579
	.2000	7.8746	10.3182	2.0636					
157	1163.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.4800	12.8900	12500.0000	600.0000	1.000	.7200	.0248
	.2000	3.4362	6.1718	1.2344					
158	1164.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.3800	15.0700	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.7203	5.0038	1.0008					
159	1165.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.4100	7.9800	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.9351	5.3837	1.0767					
160	1166.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.2100	3.7500	12500.0000	600.0000	1.000	.7200	.0248
	.2000	1.5033	2.0384	.4077					
161	1167.0000	1.000	2.0000	1.000	700.0000	.3750	3.4000	12.1000	.6984
	5.0000	5.0000	1.1300	13.0400	12500.0000	350.0000	1.000	1.8300	.2810
	.2000	8.0894	10.4528	2.0906					
162	1168.0000	1.000	2.0000	1.000	700.0000	.3750	3.4000	12.1000	.6984
	5.0000	5.0000	.8600	16.2200	12500.0000	350.0000	1.000	1.8300	.2810
	.2000	6.1565	9.0876	1.8175					
163	1169.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	.8800	3.2400	12500.0000	350.0000	1.000	1.8300	.0579
	.2000	6.2997	9.2025	1.8405					
164	1170.0000	1.000	2.0000	1.000	700.0000	.3750	.7000	12.1000	.6984
	5.0000	5.0000	.7800	4.5700	12500.0000	350.0000	1.000	1.8300	.0579
	.2000	5.5838	8.5994	1.7199					
165	1171.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.3200	8.6200	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.2908	4.1445	.8289					
166	1172.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.3100	10.4600	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.2192	3.9858	.7972					
167	1173.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.3300	8.4100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.3624	4.2994	.8597					
168	1174.0000	1.000	2.0000	1.000	700.0000	.3750	.3000	12.1000	.6984
	5.0000	5.0000	.2900	11.6100	12500.0000	600.0000	1.000	.7200	.0248
	.2000	2.0760	3.6523	.7305					
169	1175.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	6.2200	6.5800	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.7690	18.4513	2.0501					
170	1176.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.2300	4.2200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.0344	12.5537	1.3949					
171	1177.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	6.3300	3.5300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.9069	10.3324	2.0677					
172	1178.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	5.4200	7.3300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.7698	17.2122	1.9125					
173	1179.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.9230	4.9900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.8962	14.2962	1.5885					

174	1180.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.3900	3.9300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.2343	12.9889	1.4432					
175	1181.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	2.1900	6.9900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.7354	9.0565	1.0063					
176	1182.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.1200	6.8690	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.8970	12.2419	1.3602					
177	1183.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	5.2800	6.6100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.5949	9.4315	1.8863					
178	1184.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.2300	4.6800	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.0344	12.5537	1.3949					
179	1185.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	2.3500	6.2400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.9352	9.6911	1.0768					
180	1186.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	1.7700	8.0200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.2108	7.1402	.7934					
181	1187.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	8.0000	8.0000	8.9100	3.1000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	11.1290	19.2764	2.4096					
182	1188.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	8.3100	4.4300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	10.3795	21.0585	2.3398					
183	1189.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	6.2900	6.0000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.8565	18.5520	2.0613					
184	1190.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	8.0000	8.0000	2.4900	3.6700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.1101	9.0773	1.1347					
185	1191.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	2.6400	3.2400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.2975	10.7384	1.1932					
186	1192.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	2.6200	3.3600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.2725	10.6700	1.1856					
187	1193.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.1300	6.2900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.9095	12.2707	1.3934					
188	1194.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	11.3500	2.5200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	14.1766	13.2580	2.6516					
189	1195.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	5.0000	4.6100	6.5600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.7581	15.7554	1.7506					
190	1196.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	7.0000	7.0000	2.6200	5.5700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.2725	8.2989	1.1856					
191	1197.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	7.0000	7.0000	3.1100	7.4600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.8845	9.4990	1.3570					
192	1198.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	6.4700	3.4100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.0813	8.3582	2.0896					
193	1199.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	3.4200	3.6100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.2717	13.0682	1.4520					
194	1200.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	12.0000	12.0000	2.1000	2.7400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.6230	11.5718	.9643					
195	1201.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	1.4100	2.6100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	1.7611	5.6597	.5663					

196	1202.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	1.6000	7.0800	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	1.9985	3.4619	.6924					
197	1203.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	4.1000	4.0200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.1211	9.8002	1.6334					
198	1204.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	.7600	4.3300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	.9493	-.26030	-.05206					
199	1205.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	5.0400	3.1700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.2952	18.3978	1.8398					
200	1206.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	3.1100	6.9100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.8845	13.5700	1.3570					
201	1207.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	2.3000	6.3900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.8728	5.2764	1.0553					
202	1208.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	11.4400	3.8700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	14.2890	26.5949	2.6595					
203	1209.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	11.0000	11.0000	3.1100	1.8500	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.9845	14.9270	1.3570					
204	1210.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	6.4200	3.7700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.0188	20.8179	2.0818					
205	1211.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	4.6900	4.3200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.8580	17.6781	1.7678					
206	1212.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	2.9500	3.8200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.6847	5.2167	1.3042					
207	1213.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	11.0000	11.0000	2.5500	6.4400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.1851	12.7432	1.1585					
208	1214.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	40.0000	40.0000	3.9500	2.7200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.9337	63.8437	1.5961					
209	1215.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	6.8500	6.1400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.5559	8.5865	2.1466					
210	1216.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	6.2200	2.9900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.7690	8.2006	2.0501					
211	1217.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	9.4700	5.0100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	11.8284	12.3525	2.4705					
212	1218.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	4.7400	3.5200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.9205	8.8921	1.7784					
213	1219.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	8.9300	5.5900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	11.1539	12.0590	2.4118					
214	1220.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	4.5700	7.4300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.7081	8.7094	1.7419					
215	1221.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	4.3100	4.4700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.3834	16.8331	1.6833					
216	1222.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	4.4400	2.5200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.5457	17.1303	1.7130					
217	1223.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	11.0000	11.0000	4.8600	3.3700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.0703	19.8376	1.8034					

218	1224.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	4.7300	4.1600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.9080	17.7630	1.7763					
219	1225.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	3.6600	4.9900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.5715	6.0794	1.5198					
220	1226.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	4.0800	1.7600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.0961	6.5139	1.6285					
221	1227.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	4.7800	1.6600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.9704	17.8682	1.7868					
222	1228.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	14.4000	6.6100	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	17.9862	28.8960	2.8896					
223	1229.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	9.0000	9.0000	6.2300	1.8000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.7815	18.4658	2.0518					
224	1230.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	5.9400	3.4700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.4193	20.0408	2.0041					
225	1231.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	5.0700	2.9200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.3326	18.4572	1.8457					
226	1232.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	6.5700	12.5200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.2062	8.4196	2.1049					
227	1233.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	2.8600	10.6400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	3.5723	5.0928	1.2732					
228	1234.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	5.0000	5.0000	2.1900	4.1700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.7354	5.0314	1.0063					
229	1235.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	6.9900	2.0400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.7338	8.6674	2.1669					
230	1236.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	12.9800	4.9300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	16.2126	27.8578	2.7858					
231	1237.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	6.8300	3.7400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.5310	21.4373	2.1437					
232	1238.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	3.6900	5.5000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.6090	6.1120	1.5280					
233	1239.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	1.7000	3.7900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	2.1234	4.5180	.7530					
234	1240.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	7.0000	7.0000	7.3800	4.7700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	9.2179	15.5481	2.2211					
235	1241.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	4.0000	4.0000	5.1800	3.2300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.4700	7.4587	1.8672					
236	1242.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	3.9800	3.2800	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.9712	16.0366	1.6037					
237	1243.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	3.4000	3.5300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.2467	8.6769	1.4462					
238	1244.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	5.0400	3.9300	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.2952	11.0387	1.8398					
239	1245.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	6.4400	3.5000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.0438	12.5094	2.0849					

240	1246.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	2.0000	2.0000	4.3400	20.9000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.4208	3.3805	1.6902					
241	1247.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	5.1200	7.3400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.3951	11.1332	1.8555					
242	1248.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	3.4800	3.3000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	4.3467	8.8165	1.4694					
243	1249.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	6.7300	7.7700	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.4061	12.7757	2.1290					
244	1250.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	6.5500	3.0900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.1812	12.6111	2.1018					
245	1251.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	4.6800	3.7400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.8455	10.5940	1.7657					
246	1252.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	4.4600	4.6200	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.5707	10.3052	1.7175					
247	1253.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	6.0000	6.0000	5.9900	5.4900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	7.4818	12.0748	2.0125					
248	1254.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	3.0000	3.0000	11.1500	6.1500	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	13.9268	7.9014	2.6338					
249	1255.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	2.0000	2.0000	9.4600	8.2400	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	11.8159	4.9389	2.4694					
250	1256.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	15.0000	15.0000	6.5500	3.4500	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	8.1812	31.5276	2.1018					
251	1257.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	16.0000	16.0000	4.1000	4.4900	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.1211	26.1338	1.6334					
252	1258.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	15.0000	15.0000	5.2300	2.9600	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.4950	28.0655	1.8710					
253	1259.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	15.0000	15.0000	4.6000	4.0000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	5.7456	26.2265	1.7484					
254	1260.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.6984
	10.000	10.000	5.5400	2.8000	12500.0000	77.0000	1.000	47.0000	1.3802
	1.1463	6.9197	19.3437	1.9344					
258	6021.0000	1.000	1.000	1.000	670.0000	.3750	13.0000	3.8000	1.1230
	8.0000	8.0000	2.8700	2.6400	12500.0000	77.0000	2.0000	21.0000	3.4211
	2.3600	1.0829	.6373	.0797					
259	6022.0000	1.000	1.000	1.000	730.0000	.3750	13.0000	3.8000	.4748
	8.0000	8.0000	1.2600	1.6800	12500.0000	77.0000	2.0000	21.0000	3.4211
	2.3600	1.1246	.9392	.1174					
260	6023.0000	1.000	1.000	1.000	670.0000	.3750	13.0000	14.8000	1.1230
	8.0000	8.0000	1.3390	1.4300	12500.0000	77.0000	2.0000	21.0000	.8784
	.4088	2.8972	8.5100	1.0638					
261	6024.0000	1.000	1.000	1.000	730.0000	.3750	13.0000	14.8000	.4748
	8.0000	8.0000	1.0900	1.4000	12500.0000	77.0000	2.0000	21.0000	.8784
	.4088	5.6164	13.8055	1.7257					
262	6025.0000	1.000	1.000	1.000	700.0000	.3750	13.0000	9.8000	.6984
	12.0000	12.0000	1.1400	1.6400	12500.0000	77.0000	2.0000	21.0000	1.3265
	1.0551	1.5470	5.2355	.4363					
263	6026.0000	1.000	1.000	1.000	700.0000	.3750	13.0000	9.4000	.6984
	4.0000	4.0000	1.2300	1.4800	12500.0000	77.0000	2.0000	21.0000	1.3830
	1.1511	1.5299	1.7009	.4252					
264	6027.0000	1.000	1.000	1.000	700.0000	.3750	13.0000	1.5000	.6984
	4.0000	4.0000	2.1500	3.5300	12500.0000	77.0000	2.0000	21.0000	8.6667
	2.9580	1.0407	.1534	.0399					

265	6028.0000	1.000	1.000	1.000	700.0000	.3750	13.0000	17.0000	.6984
	4.0000	4.0000	3.1200	3.4300	12500.0000	77.0000	2.0000	21.0000	.7647
	.3235	13.8073	10.5008	2.6252					
266	6029.0000	1.000	1.000	1.000	650.0000	.3750	13.0000	9.8000	1.4745
	4.0000	4.0000	2.0600	2.3500	12500.0000	77.0000	2.0000	21.0000	1.3265
	1.0551	1.3241	1.1230	.2808					
267	6020.0000	1.000	1.000	1.000	750.0000	.3750	13.0000	9.8000	.4017
	4.0000	4.0000	.7000	2.4000	12500.0000	77.0000	2.0000	21.0000	1.3265
	1.0551	1.6515	2.0068	.5017					
277	6611.0000	4.0000	2.0000	1.000	400.0000	.5000	7.7000	10.000	5.9000
	34.0000	21.0000	8.8400	.9000	7800.0000	300.0000	2.0000	1.7500	.7700
	.3275	4.5750	31.9326	1.5206					
278	6612.0000	4.0000	2.0000	1.000	400.0000	.5000	7.7000	10.000	5.9000
	14.0000	10.000	15.7000	.6600	7800.0000	300.0000	2.0000	1.7500	.7700
	.3275	8.1252	20.9497	2.0950					
279	6613.0000	4.0000	2.0000	1.000	400.0000	.5000	8.7000	10.000	5.9000
	14.0000	6.0000	13.6000	.6600	7800.0000	300.0000	1.000	2.4000	.8700
	.4025	5.7269	10.4711	1.7452					
280	6614.0000	4.0000	2.0000	1.000	400.0000	.5000	8.7000	10.000	5.9000
	10.000	6.0000	9.3000	.8300	7800.0000	300.0000	2.0000	1.7500	.8700
	.4025	5.9162	8.1907	1.3651					
281	6615.0000	4.0000	2.0000	1.000	400.0000	.5000	25.6000	10.000	5.9000
	13.0000	13.0000	7.3000	.8800	7800.0000	300.0000	2.0000	4.2000	2.5600
	2.2618	.5470	-7.84233	-.60336					
282	6616.0000	4.0000	2.0000	1.000	400.0000	.5000	25.6000	10.000	5.9000
	18.0000	11.0000	6.4000	.9000	7800.0000	300.0000	2.0000	4.2000	2.5600
	2.2618	.4796	-9.08316	-.73483					
283	6617.0000	4.0000	2.0000	1.000	400.0000	.5000	8.7000	1 .000	5.9000
	14.0000	14.0000	5.9500	1.8000	7800.0000	300.0000	2.0000	1.7500	.8700
	.4025	1.2422	3.0368	.2169					
284	6618.0000	4.0000	2.0000	1.000	400.0000	.5000	7.7000	10.000	5.9000
	16.0000	11.0000	2.7000	.5100	7800.0000	300.0000	2.0000	1.7500	.7700
	.3275	1.3373	3.6802	.3346					
285	6619.0000	4.0000	2.0000	1.000	400.0000	.5000	7.7000	10.000	5.9000
	31.0000	23.0000	1.9200	.6300	7800.0000	300.0000	2.0000	1.7500	.7700
	.3275	.9937	-.14628	-.00635					
291	6711.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	12.1000	.7258
	18.0000	18.0000	4.4400	1.9700	12500.0000	77.0000	2.0000	21.0000	1.3802
	1.1463	5.3365	30.1422	1.6746					
292	6712.0000	1.000	2.0000	2.0000	700.0000	.3750	16.7000	12.1000	.7258
	10.000	10.000	6.3300	2.7000	12500.0000	77.0000	2.0000	21.0000	1.3802
	1.1463	7.6802	20.3864	2.0386					
293	6713.0000	1.000	2.0000	2.0000	700.0000	.3750	16.7000	12.1000	.7258
	10.000	10.000	13.9900	1.7500	12500.0000	77.0000	2.0000	21.0000	1.3802
	1.1463	16.8147	28.2225	2.8223					
294	6714.0000	1.000	2.0000	2.0000	700.0000	.3750	16.7000	12.3000	.7258
	10.000	10.000	23.6100	2.8400	12500.0000	77.0000	2.0000	21.0000	1.3577
	1.1041	29.3540	33.7345	3.3794					
295	6721.0000	4.0000	2.0000	1.000	30.0000	.1970	10.4000	5.8000	2.3000
	45.0000	9.0000	9.0000	1.2300	3400.0000	250.0000	3.0000	4.5000	1.7931
	1.4483	2.1689	6.9479	.7742					
296	6722.0000	4.0000	2.0000	1.000	30.0000	.1970	10.5000	5.8000	4.7600
	63.0000	28.0000	13.6400	1.6000	3400.0000	250.0000	3.0000	4.5000	1.6103
	1.8776	1.5318	11.9401	.4264					
300	6821.0000	3.0000	2.0000	2.0000	800.0000	.4380	15.3000	.8000	4.9302
	22.0000	7.0000	315.0000	1.6000	10000.0000	150.0000	3.0000	150.0000	24.1250
	3.0000	21.2973	21.4100	3.0586					
301	6822.0000	3.0000	2.0000	1.000	800.0000	.4380	15.3000	.8000	4.9302
	28.0000	11.0000	84.0000	1.3000	10000.0000	150.0000	3.0000	150.0000	24.1250
	3.0000	5.6793	18.1051	1.7368					
302	6823.0000	3.0000	2.0000	1.000	800.0000	.4380	15.3000	.8000	4.9302
	56.0000	14.0000	101.0000	1.7000	10000.0000	150.0000	3.0000	150.0000	24.1250
	3.0000	6.4287	26.8858	1.9211					
315	7111.0000	3.0000	2.0000	1.000	800.0000	.5000	20.1000	.8000	5.2041
	30.0000	20.0000	4.3000	1.5600	10000.0000	150.0000	7.0000	150.0000	25.1250
	3.0000	.2620	-26.73226	-1.53951					

316	7112.0000	3.0000	2.0000	1.000	800.0000	.5000	20.1000	.8000	5.2041
	29.0000	23.0000	4.5700	1.8700	10000.0000	150.0000	7.0000	150.0000	25.1250
	3.0000	.2927	-24.25653	-1.22854					
317	7113.0000	3.0000	2.0000	1.000	800.0000	.5000	20.1000	.8000	5.3410
	29.0000	26.0000	3.3300	1.1600	10000.0000	150.0000	7.0000	150.0000	25.1250
	3.0000	.2078	-40.84761	-1.57106					
319	7211.0000	1.000	2.0000	1.000	700.0000	.3750	16.7000	**12.7000**	.6984
	10.000	**10.000**	1.5600	2.5800	12500.0000	77.0000	2.0000	**21.0000**	1.3150
	1.0354	**2.1571**	7.6877	.7688					
320	7212.0000	**1.000**	2.0000	1.000	700.0000	.3750	16.7000	**12.7000**	.6984
	10.000	**10.000**	2.3400	2.1300	12500.0000	77.0000	2.0000	**21.0000**	1.3150
	1.0354	**2.8208**	10.3703	1.0370					
321	**7213.0000**	**1.000**	1.000	1.000	700.0000	.3750	16.7000	**12.7000**	.6984
	10.000	**10.000**	2.4500	2.7400	12500.0000	77.0000	2.0000	**21.0000**	1.3150
	1.0354	**3.3878**	12.2017	1.2202					
322	**7214.0000**	**1.000**	5.0000	1.000	700.0000	.3750	16.7000	**12.7000**	.6984
	12.0000	**12.0000**	2.9400	2.5100	12500.0000	77.0000	2.0000	**21.0000**	1.3150
	1.0354	**4.0653**	16.8299	1.4025					
323	7215.0000	1.000	5.0000	1.000	700.0000	.3750	16.7000	12.7000	.6984
	15.0000	15.0000	4.0800	3.0900	12500.0000	77.0000	2.0000	21.0000	1.3150
	1.0354	5.6417	25.9527	1.7302					
324	7216.0000	1.000	5.0000	1.000	700.0000	.3750	16.7000	12.7000	.6984
	11.0000	11.0000	4.1900	3.1800	12500.0000	77.0000	2.0000	21.0000	1.3150
	1.0354	5.7938	13.3246	1.7568					
325	7217.0000	1.000	5.0000	1.000	700.0000	.3750	16.7000	12.7000	.6984
	9.0000	9.0000	5.6620	6.5200	12500.0000	77.0000	2.0000	21.0000	1.3150
	1.0354	7.8264	13.5175	2.0575					
332	7511.0000	2.0000	4.0000	1.000	680.0000	1.1250	4.0000	.7000	5.9345
	11.0000	10.000	3.1720	1.7600	3600.0000	158.0000	1.000	9.6000	5.7143
	2.6214	.2036	-15.99770	-1.59077					
335	7621.0000	2.0000	4.0000	1.000	680.0000	1.1250	4.0000	.7000	5.9345
	12.0000	12.0000	10.8600	3.0100	3600.0000	158.0000	1.000	9.6000	5.7143
	2.6214	.6981	-4.31299	-.35942					
336	7631.0000	2.0000	2.0000	1.000	680.0000	1.1250	4.0000	.7000	5.9345
	12.0000	12.0000	2.1000	1.3100	3600.0000	158.0000	1.000	9.6000	5.7143
	2.6214	.1350	-24.33076	-2.00256					
339	7721.0000	1.000	2.0000	1.000	700.0000	.3750	13.0000	12.2000	.7167
	72.0000	72.0000	3.0200	3.0800	10000.0000	100.0000	2.0000	13.5000	1.3656
	.6115	6.8911	134.9765	1.9302					
340	7731.0000	4.0000	4.0000	1.000	600.0000	.9370	7.5000	.1000	5.9000
	15.0000	15.0000	23.7200	1.9900	7800.0000	300.0000	2.0000	1.7500	1.4706
	1.3000	3.0326	16.9350	1.1290					
341	7732.0000	4.0000	4.0000	3.0000	600.0000	.9370	7.5000	5.4000	5.9000
	30.0000	30.0000	15.3900	1.8000	7800.0000	300.0000	2.0000	1.7500	1.2731
	.9983	2.6130	23.8148	.9605					
342	7741.0000	3.0000	4.0000	1.000	800.0000	.5000	20.1000	.8000	5.2041
	40.0000	34.0000	3.9000	1.3300	10000.0000	150.0000	4.0000	21.0000	25.1250
	3.0000	.8701	-13.13826	-.56201					
348	7831.0000	4.0000	2.0000	1.000	600.0000	.2890	1.1000	4.1000	1443.0000
	9.0000	7.0000	32.1500	.6400	10770.0000	200.0000	2.0000	3.5000	.2683
	.2000	.1114	-15.36240	-2.19463					
349	7832.0000	**4.0000**	2.0000	1.000	500.0000	.2890	1.1000	4.1000	8046.0000
	9.0000	**7.0000**	92.3100	.9200	10770.0000	200.0000	2.0000	**3.5000**	.2683
	.2000	**.0574**	-20.00436	-2.85834					
350	7833.0000	**4.0000**	2.0000	1.000	600.0000	.0130	1.1000	**4.1000**	1443.0000
	4.0000	**4.0000**	1.8700	.5900	10770.0000	200.0000	2.0000	**3.5000**	.2683
	.2000	**.0065**	-20.15640	-5.03910					
351	7834.0000	4.0000	3.0000	1.000	500.0000	.0130	1.1000	**4.1000**	8046.0000
	5.0000	4.0000	27.5300	.6800	10770.0000	200.0000	2.0000	**3.5000**	.2683
	.2000	.0171	-16.27285	-4.06822					
354	7861.0000	1.000	4.0000	1.000	700.0000	.3750	13.0000	12.1000	.6984
	13.0000	13.0000	2.7300	3.0900	12500.0000	77.0000	2.0000	21.0000	1.0744
	.6264	6.2395	23.8016	1.8309					
355	7862.0000	1.000	2.0000	1.000	700.0000	.3750	13.0000	12.1000	.6984
	11.0000	11.0000	3.0000	2.6300	12500.0000	77.0000	2.0000	21.0000	1.0744
	.6264	6.8565	21.1772	1.9252					

356	7863.0000	1.000	1.000	1.000	700.0000	.3[illegible]00	13.0000	12.1000	.6984
	15.0000	15.0000	2.8700	2.6400	12500.0000	77.0000	2.0000	21.0000	1.0744
	.6264	6.5594	25.2136	1.8809					

NUMBER OF CASES READ.	359
CASES WITH USE SET TO ZERO	53
REMAINING NUMBER OF CASES	306

APPENDIX B

DATA BASE FOR BEARINGS

AL79T027

CASE LABEL NO.	1 [illegible] / 10 [illegible] / 19 [illegible]	2 TYPE / 11 [illegible] / 20 MATFAC	3 MAT / 12 [illegible] / 21 [illegible]	4 PROC / 13 META / 22 LOGMAT	5 STRESS / 14 SPEED	6 SIZE / 15 TEMP	7 H / 16 LUBE	8 SIGMA / 17 VIS	9 L10TH / 18 H/SIG
255	[illegible]11.[illegible]	10.000	2.0000	1.000	480.0000	1.7700	3.9000	8.0000	10.000
	32.[illegible]	15.0000	35.3700	.9100	1500.0000	144.0000	6.0000	60.0000	.4875
	.2[illegible]	19.1500	44.2924	2.9525					
256	5612.0000	10.000	2.0000	1.000	480.0000	1.7700	4.3000	8.0000	10.000
	31.0000	22.0000	5.0630	1.1100	1500.0000	165.0000	2.0000	4.2000	.5375
	.2000	4.0300	37.6624	1.3938					
257	5431.0000	10.000	2.0000	1.000	480.0000	1.7700	3.9000	8.0000	10.000
	[illegible]	27.0000	35.1000	1.4000	1500.0000	155.0000	6.0000	25.0000	.4875
	.2000	17.5530	60.2215	2.4651					
268	6111.0000	10.000	1.000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	30.0000	30.0000	3.1100	1.1100	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2422	.1557	-59.92222	-1.99741					
269	6112.0000	10.000	1.000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	30.0000	28.0000	5.3900	1.6600	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2422	.2775	-25.84604	-1.26200					
270	6113.0000	10.000	1.000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	30.0000	15.0000	16.5300	1.1100	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2425	.7212	-4.90281	-.32665					
271	6411.0000	10.000	2.0000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	25.0000	15.0000	120.5700	1.0700	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2420	[illegible]	26.5532	1.6602					
272	6411.[illegible]	10.000	4.0000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	10.000	[illegible]	22.4000	1.0300	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2420	.9773	-.13782	-.02297					
273	6421.0000	10.000	3.0000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	10.000	4.0000	35.9900	1.1100	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2420	1.5702	1.8345	.4512					
274	[illegible]	10.000	3.0000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	10.000	[illegible]	14.7400	1.2400	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2420	.7431	-3.09020	-.44147					
275	6423.0000	10.000	3.0000	1.000	480.0000	1.7700	6.0000	8.0000	10.000
	14.000	4.0000	15.2200	.6500	9700.0000	240.0000	5.0000	4.4000	.7500
	.3125	4.8704	[illegible].3327	1.5832					
276	6424.[illegible]	10.000	3.0000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	13.100	2.0000	75.7100	.7600	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2420	3.3453	2.4166	1.2080					
286	5421.0000	10.000	2.0000	2.0000	670.0000	1.3780	12.0000	8.0000	1.6800
	[illegible]	[illegible]	94.3900	2.3600	12900.0000	77.0000	2.0000	29.0000	1.5000
	1.350	41.8182	[illegible]	3.7285					
287	6622.0000	10.000	2.0250	1.000	670.0000	1.3780	12.0000	8.0000	1.6800
	27.0000	27.0000	9.5500	1.0700	12000.0000	77.0000	2.0000	29.0000	1.5000
	1.5550	4.2019	35.7579	1.4355					
288	6631.0000	10.000	[illegible]	2.0000	480.0000	1.7700	5.5000	8.0000	10.000
	31.0000	25.0000	5.0700	.8000	9700.0000	212.0000	1.000	5.0000	.6875
	.2655	1.4467	15.1606	.6464					
289	6632.0000	10.000	2.0000	1.000	480.0000	1.7700	5.5000	8.0000	10.000
	30.0000	30.0000	175.5900	1.2500	9700.0000	212.0000	1.000	5.0000	.6875
	.2656	73.6339	125.9731	4.2991					
290	6641.0000	10.000	3.0000	1.000	480.0000	1.7700	22.6000	8.0000	10.000
	30.0000	12.0000	199.6900	2.2900	9700.0000	212.0000	3.0000	12.7000	2.8250
	2.2420	5.7123	25.9768	2.1647					
297	6751.0000	10.000	2.0000	1.000	480.0000	1.7700	5.5000	4.0000	10.000
	11.6000	2.0000	[illegible]	1.4700	9700.0000	212.0000	1.000	5.0000	1.3750
	1.1375	24.[illegible]	5.4132	3.2156					
298	6811.0000	11.0000	2.0000	1.000	340.0000	4.7240	12.8000	2.8000	15.2100
	26.0000	[illegible]	152.0[illegible]	1.4000	12000.0000	600.0000	3.0000	2.1000	4.5714
	2.4411	4.4133	9.4159	1.5693					
299	6812.0000	11.[illegible]	2.0000	1.000	340.0000	4.7240	19.3000	2.8000	30.3400

	17.0000	4.0000	92.0000	1.4000	12000.0000	600.0000	5.0000	1.8500	6.8927
	2.7557	1.1003	.3525	.0956					
303	6831.0000	12.0000	2.0000	1.000	190.0000	2.9530	14.8000	11.7000	16.1200
	6.0000	4.0000	5.7570	1.3300	2545.0000	118.0000	1.000	18.0000	1.2650
	.9504	.3773	-3.84924	-.97461					
304	6832.0000	12.0000	2.0000	1.000	250.0000	2.3620	45.9000	11.7000	13.4100
	6.0000	4.0000	2.4000	1.3600	2545.0000	150.0000	1.000	11.0000	3.9231
	2.4172	.1655	-2.15554	-1.79222					
305	6833.0000	12.0000	2.0000	1.000	260.0000	3.9370	10.8000	8.5000	6.1000
	6.0000	5.0000	5.5500	2.4900	1050.0000	116.0000	1.000	18.0000	1.2706
	.4550	.9495	-.25934	-.05187					
306	6834.0000	12.0000	2.0000	1.000	290.0000	2.1650	90.6000	10.6000	4.4700
	6.0000	2.0000	22.5960	1.1900	7540.0000	170.0000	1.000	7.9000	8.5472
	2.9444	2.1723	1.5515	.7756					
307	6835.0000	12.0000	2.0000	1.000	190.0000	1.3780	36.8000	8.9000	21.5300
	6.0000	4.0000	33.2500	.9400	19360.0000	135.0000	1.000	14.0000	4.1348
	2.4414	1.0135	.0542	.0136					
308	6836.0000	12.0000	2.0000	1.000	250.0000	2.3620	101.6000	8.9000	11.9800
	6.0000	1.000	115.3000	.4900	7540.0000	175.0000	1.000	7.7000	11.4157
	3.0000	3.2061	1.1657	1.1657					
309	6841.0000	11.0000	2.0000	1.000	300.0000	5.5120	13.0000	1.8000	12.4800
	20.0000	4.0000	272.9644	1.6400	10000.0000	325.0000	1.000	2.1000	7.2222
	2.7933	7.4450	5.2905	2.0726					
310	6911.0000	11.0000	2.0000	1.000	320.0000	4.7240	10.000	2.6000	15.3000
	23.0000	10.000	215.0000	1.7000	12000.0000	400.0000	3.0000	5.8000	3.5714
	2.5771	5.4504	17.5754	1.7575					
311	6912.0000	11.0000	2.0000	1.000	320.0000	4.7240	6.8000	2.8000	15.3000
	25.0000	11.0000	255.0010	3.2000	12000.0000	500.0000	3.0000	3.2000	2.4286
	2.2467	4.3145	23.3347	2.1145					
312	6913.0000	11.0000	2.0000	1.000	320.0000	4.7240	5.0000	2.8000	15.3000
	25.0000	6.0000	122.0500	1.8000	12000.0000	600.0000	3.0000	2.1000	1.7857
	1.8357	5.4500	11.2123	1.5687					
313	6921.0000	11.0000	2.0000	1.000	0.000	1.7700	22.6000	4.0000	10.000
	10.000	3.0000	[illegible]	1.1700	9700.0000	212.0000	3.0000	12.7000	5.6500
	2.6141	5.4730	5.5129	1.5676					
314	7011.0000	10.0000	5.0000	1.000	0.000	1.7700	9.1000	4.0000	10.000
	30.0000	4.0000	5.9100	2.5500	20000.0000	212.0000	1.000	5.0000	2.2750
	2.2243	3.2742	12.4125	1.3013					
316	7121.0000	11.0000	2.0000	1.000	320.0000	4.7200	5.0000	2.8000	13.4000
	26.0000	6.0000	122.0500	1.6000	12000.0000	600.0000	3.0000	2.1000	1.7857
	1.8357	7.3455	12.0079	2.0013					
326	7221.0000	11.0000	2.0000	1.000	320.0000	4.7240	18.8000	2.9000	13.4000
	29.0000	17.0000	54.0000	1.4000	12000.0000	425.0000	5.0000	.0100	6.4828
	2.7090	1.7635	4.6395	.5670					
327	7222.0000	11.0000	2.0000	1.000	320.0000	4.7240	23.8000	2.9000	13.4000
	27.0000	14.0000	143.0000	1.9000	12000.0000	425.0000	3.0000	.0200	8.2069
	2.9555	3.5955	17.9155	1.2798					
328	7231.0000	10.000	2.0000	1.000	480.0000	1.7700	22.6000	4.0000	10.8000
	20.0000	2.0000	2.1500	20.3700	9700.0000	212.0000	3.0000	12.7000	5.6500
	2.6141	.1109	-4.39445	-2.19943					
329	7411.0000	11.0000	2.0000	1.000	320.0000	4.7240	18.6000	2.2000	23.5000
	20.0000	13.0000	352.0000	1.7000	12000.0000	500.0000	3.0000	3.2000	8.4545
	2.9135	4.3503	19.2126	1.4771					
330	7412.0000	11.0000	2.0000	1.000	320.0000	4.7240	18.4000	2.2000	15.2100
	30.0000	20.0000	159.0000	1.6700	12000.0000	500.0000	3.0000	3.2000	8.3636
	2.9235	3.5754	25.4537	1.2742					
331	7413.0000	11.0000	2.0000	1.000	360.0000	4.7240	18.2000	2.2000	7.5000
	40.0000	24.0000	43.0000	3.3200	12000.0000	500.0000	3.0000	3.2000	8.2727
	2.9131	3.7907	22.0334	1.3347					
333	7611.0000	11.0000	4.0000	1.000	320.0000	4.7240	8.2000	2.2000	25.9200
	30.0000	1.000	2700.0000	2.1000	12000.0000	425.0000	5.0000	1.3100	3.7273
	2.3944	43.4951	3.7725	3.7726					
334	7612.0000	11.0000	4.0000	1.000	320.0000	4.7240	13.6000	2.2000	15.8000
	30.0000	6.0000	2400.0000	2.1000	25000.0000	425.0000	5.0000	1.3100	6.1818
	2.5747	55.7904	24.2362	4.0394					
337	7641.0000	10.000	2.0000	1.000	300.0000	1.3800	42.3000	6.3000	23.1100

	4.0000	3.0000	43.4200	1.0500	65000.0000	180.0000	2.0000	4.6000	6.7143
	2.7354	.6869	-1.12690	-.37563					
338	7642.0000	10.000	2.0000	2.0000	300.0000	1.3800	42.3000	6.3000	23.1100
	10.000	3.0000	194.2100	18.1000	65000.0000	180.0000	2.0000	4.6000	6.7143
	2.7354	3.0722	3.3672	1.1224					
343	7311.0000	11.0000	4.0000	1.000	450.0000	4.3310	1.3000	3.6000	1.3300
	6.0000	2.0000	8.7400	1.9000	324.0000	200.0000	2.0000	3.6000	.3611
	.2000	33.0075	6.9935	3.4967					
344	7812.0000	11.0000	0.000	1.000	460.0000	2.3620	1.000	6.6000	3.0800
	8.0000	4.0000	.7200	.5000	324.0000	200.0000	2.0000	3.6000	.1515
	.2000	1.1688	.6240	.1560					
345	7813.0000	11.0000	0.000	1.000	460.0000	2.3620	1.000	3.6000	3.0800
	9.0000	2.0000	6.2400	.7000	324.0000	200.0000	2.0000	3.6000	.2778
	.2000	10.1299	4.6310	2.3155					
346	7821.0000	10.000	2.0000	1.000	0.000	1.5740	2.0000	5.9000	11.2000
	30.0000	22.0000	6.1000	.5400	3200.0000	212.0000	2.0000	3.0000	.3390
	.2000	2.7232	22.0339	1.0018					
347	7822.0000	10.000	2.0000	1.000	0.000	1.5740	2.0000	5.2000	11.2000
	25.0000	23.0000	3.3000	.5900	3200.0000	212.0000	2.0000	3.0000	.3846
	.2000	1.4232	8.9113	.3274					
352	7841.0000	14.0000	2.0000	1.000	230.0000	3.3460	7.9000	5.0000	84.5900
	47.0000	11.0000	37.4600	1.7200	887.0000	165.0000	1.000	8.7000	1.5600
	1.4560	.2480	-13.31692	-1.21063					
353	7842.0000	14.0000	2.0000	1.000	270.0000	2.7560	3.1000	5.0000	19.4600
	109.0000	17.0000	18.7700	2.6800	243.0000	165.0000	2.0000	5.2000	.6200
	.2150	4.4452	25.5173	1.7010					
357	7911.0000	11.0000	4.0000	1.000	260.0000	1.7710	14.3000	7.2000	122.0000
	17.0000	10.000	59.0000	1.000	5500.0000	158.0000	1.000	9.7000	1.9861
	2.1764	.2222	-15.04149	-1.50415					
358	7912.0000	12.0000	1.000	1.000	270.0000	1.7710	21.6000	5.4000	3.9400
	19.0000	2.0000	314.0000	.5400	9700.0000	162.0000	1.000	9.3000	4.0000
	2.4260	32.8556	6.9859	3.4620					
359	7913.0000	10.000	4.0000	1.000	450.0000	1.1770	27.5000	9.5000	10.9000
	20.0000	18.0000	64.2000	2.6100	21200.0000	175.0000	1.000	7.5000	2.6947
	2.3000	2.5508	16.9260	.9403					
360	7921.0000	11.0000	4.0000	1.000	190.0000	1.7720	16.0000	5.0000	209.0000
	10.000	?.400	400.0000	1.000	5500.0000	158.0000	1.000	10.?00	3.2?00
	2.33?8	.?197	0.000	-.19?30					
361	7922.0000	11.0000	4.0000	1.000	270.0000	1.7720	15.4000	5.0000	46.5000
	10.000	2.0000	690.0000	2.?000	5500.0000	156.0000	1.000	10.000	3.0800
	2.3211	5.5591	3.4399	1.7154					
362	7923.0000	11.0000	4.0000	1.000	250.0000	1.7720	18.2000	5.0000	10.000
	10.000	5.0000	53.0000	1.1?00	9700.0000	181.0000	1.000	7.6000	3.6400
	2.?452	?.?223	3.9936	.74?					
363	7924.0000	11.0000	4.0000	1.000	250.0000	1.7720	11.7000	5.0000	10.000
	10.000	4.0000	60.3000	.9900	9700.0000	174.0000	2.0000	4.2000	2.3400
	2.2368	2.6959	3.?064	.9?17					
364	7925.0000	11.0000	4.0000	1.000	250.0000	1.7720	4.9000	5.0000	10.000
	10.000	0.000	90.0000	1.000	350.0000	86.0000	1.000	38.0000	.9800
	[illegible]	18.??67	0.000	2.9??4					

NUMBER OF CASES READ. 364
CASES WITH USE SET TO ZERO 306
REMAINING NUMBER OF CASES 58

DISTRIBUTION LIST

Director
Propulsion Laboratory M/S 77-5
US Army Research & Technology
Laboratories (AVRADCOM)
21000 Brookpark Road
Cleveland, Ohio 44135

Director
Applied Technology Laboratory
US Army Research & Technology
Laboratories (AVRADCOM)
ATTN: DAVDL-ATL-AT
Ft. Eustis, VA 23604

Director
US Army Research & Technology
Laboratories (AVRADCOM)
ATTN: DAVDL-AS M/S 207-5
Ames Research Center
Moffett Field, CA 94035

Director
US Army Research & Technology
Laboratories (AVRADCOM)
ATTN: DAVDL-POM M/S 206-4
Ames Research Center
Moffett Field, CA 94035

Commander
US Army Aviation R&D Command
ATTN: DRDAV-N
P.O. Box 209
St. Louis, MO 63166

Commander
US Army Troop Support & Aviation
Materiel Readiness Command
ATTN: DRSTS-DIL(2)
P.O. Box 209
St. Louis, MO 63166

Commander US Army Mobility Equipment R&D Command
ATTN: DRDME-ZT, Mr. Dinger
Ft. Belvoir, VA 22060

Commander
US Army Tank-Automotive R&D Command
ATTN: DRDTA-RGE, Mr. Whitcomb
Warren, MI 48090

Raymond M. Standahar
Staff Specialist for Propulsion
OSD/OUSDR&E(ET)
Rm 1809, The Pentagon
Washington, DC 20301

Chief
Army Research Office
ATTN: Mr. Murray
P.O. Box 12211
Research Triangle Park, NC 27709

Commandant
US Military Academy
ATTN: Chief, Dept. of Mechanics
West Point, NY 10996

Commander
Southwest Research Institute
US Army Fuels & Lubricants Research
Laboratory
P.O. Drawer 28510
San Antonio, TX 78284

Department of the Army
ODCSRDA (DAMA-WSA, R. Ballard)
Washington, DC 20310

Defense Documentation Center
Scientific & Technical Info.
Building No. 5
Cameron Station
Alexandria, VA 22314

NASA Headquarters
Washington, DC 20546
ATTN: RTM-6/J. J. Gangler

NASA/Lewis Research Center
21000 Brookpark Rd.
Cleveland, OH 44135
ATTN: W.L. Stewart, M.S. 3-5

AF Systems Command
Wright Patterson AFB, OH 45433
ATTN: APFL/SFL, Howard Jones

U.S. Naval Research Laboratory
Washington, DC 20390
ATTN: Charles Murphy

DISTRIBUTION LIST (cont.)

Department of the Navy
Bureau of Naval Weapons
Washington, DC 20013
ATTN: RAPP-4/C. C. Sigletorry

Department of the Navy
Naval Air Systems Command
AIR-330
Washington, DC 20360

Department of the Navy
Office of Naval Research
Arlington, VA 22217
ATTN: 411/Lt. R. Miller

U.S. Army Ordnance
Commander
Rock Island Arsenal
Rock Island, IL 61201
ATTN: SARRI-LR-M

AMMRC
Watertown, MA 02172
ATTN: Dr. R. Singler

AiResearch Manufacturing Corporation
402 S. 36th St.
Phoenix, AZ 85034
ATTN: F. Blake Wallace

AVCO Corporation
Lycoming Division
550 S. Main St.
Stratford, CT 06497
ATTN: H. Thornton

Battelle Columbus Labs.
505 King Ave.
Columbus, OH 43201
ATTN: C.M. Allen

The Boeing Aircraft Company
P.O. Box 3707
Seattle WA 98124
ATTN: W.S. Lambert, 2-1100

The Boeing-Vertol Co.
Boeing Center
P.O. Box 16858
Philadelphia, PA 19142
ATTN: J. Lenski

Borg Warner Corporation
Roy C. Ingersoll Research Center
Wolf and Algonquin Rds.
Des Plaines, IL 60018

Borg-Warner Corporation
27941 Front St.
Temecula, CA 92390
ATTN: O. Gils

Carnegie-Mellon University
Mechanical Engineering Department
Schenley Part
Pittsburgh, PA 15213
ATTN: Dr. William Hughes

Delaud Turbine Inc.
P.O. Box 251
Trenton, NJ 08602

EXXON Research & Engineering
P.O. Box 101
Florham Park, NJ 07932
ATTN: D.O. Calafell

Franklin Institute Laboratories
20th and Parkway
Philadelphia, PA 19103
ATTN: R. Colsher

Garrett Corporation
AiResearch Manufacturing Division
9851-9951 Sepulveda Blvd.
Los Angeles, CA 90009
ATTN: A. Silver

General Electric Co.
Advanced Engine & Technology Department
Cincinnati, OH 45215
ATTN: J. Clark

General Electric Co.
Bearing and Sealing System
Bldg. 53-334
One River Road
Schenectady, NY 12345
ATTN: J. McHugh

General Motors Corporation
Allison Division
Plant #3, Dept. 7339
Indianapolis, IN 46206
ATTN: E.M. Deckman

General Motors Research Laboratories
12 Mile and Mound Rds.
Warren, MI 48090
ATTN: J. Symons

Koppers Co., Inc.
Metal Products Division
P.O. Box 626
Baltimore, MD 21203
ATTN: E. Taschenburg

Mechanical Technology, Inc.
968 Albany Shaker Rd.
Latham, NY 12110
ATTN: W. Shapiro

University of Mexico
Bureau of Engineering Research
Farris Engineering Center
Albuquerque, NM 87131
ATTN: Professor A. Lebeck

Sikorsky Aircraft
N. Main Street
Stratford, CT 06497
ATTN: Carl Keller

Southwest Research Institute
P.O. Drawer 28510
San Antonio, TX 78228

Sundstrand Corporation
2480 70th St.
Denver, CO 80221
ATTN: Max Kershiswik

Sundstrand Corporation
4747 Harrison Ave.
Rockford, IL 61101
ATTN: J. Butler

Solar
P.O. Box 80966
San Diego, CA 92138
ATTN: G. Hosang

Teledyne CAE
1330 Laskey Rd.
Toledo, OH 43612
ATTN: Hugh Gaylord

The University of Tennessee
Department of Mechanical & Aerospace
Engineering
Knoxville, TN 37916
ATTN: Professor W. K. Stair

United Technologies Corporation
Pratt & Whitney Aircraft Division
Government Products Div. E-40
Box 2691
West Palm Beach, FL 33402
ATTN: L. Hollars

United Technologies Corporation
Pratt & Whitney Aircraft Division
Engineering Bldg. EB2E-2
East Hartford, CT 06018
ATTN: P. Brown

Westinghouse Electric Corporation
5100 W. 164th St.
Cleveland, OH 44142
ATTN: Lynn Powers

Westinghouse R&D Center
Pittsburgh, PA
ATTN: A. A. Raimondi

Wickes Engineered Materials
1621 Holland
Saginaw, MI
ATTN: P. Dahlenberg

Williams Research Corporation
2280 W. Maple Rd.
Walled Lake, MI 48088
ATTN: K. J. Bremner

New Hampshire Ball Bearings, Inc.
Peterborough, N.H. 03458
ATTN: Benjamin Pratt

The Torrington Co.
Bearings Division
59 Field Street
Torrington, CA 06790
ATTN: Dr. M. J. Hartnett

Rollway Bearing Co.
Syracuse, NY 13201
ATTN: F. W. Schueler

Marlin-Rockwell Div. TRW
402 Chandler St.
Jamestown, NY 14701
ATTN: Arthur S. Irwin

The Timken Co.
1835 Dueber Ave. S.W.
Canton, OH 44706
ATTN: P.S. Orvos

The Fafnir Bearing Co.
New Britain, CT 06050
ATTN: H. B. Vandorn

The Barden Corp.
Dept 76
200 Park Ave
Danbury, CT 06810
ATTN: H. R. Berglund

Industrial Tectonics Inc.
Bearings Div.
18301 S. Santa Fe
Compton, CA 90224
ATTN: H. Signer

Hughes Aircraft Co.
Bldg 6 MS E110
Centinela and Teale St.
Culver City, CA 90034

Kaman Aerospace Corp.
Old Windsor Road
Bloomfield, CT 06002
ATTN: R. B. Bossler